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## **Analysis and Treatment of a Nineteenth Century Oil Painting**

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### **Analysis and Treatment of a Nineteenth Century Oil Painting**

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## RESUMO

Esta tese focou-se no estudo e tratamento de um retrato feminino a óleo, do século XIX, do Ecomuseu Municipal do Seixal, Portugal. A pintura que retrata *Isabel Maria Lourenço Affonso* encontrava-se em mau estado de conservação e faltava-lhe uma larga tira (com aproximadamente 9cm por 66cm, quase 11% da área de superfície total da pintura). O retrato é uma peça companheira de um retrato masculino (esta relação foi estabelecida como parte deste estudo), e portanto um estudo técnico dos dois quadros foi considerado essencial para suportar as escolhas realizadas durante o tratamento.

Este projecto envolveu três áreas principais:

- O estudo da história, condição, materiais e técnicas dos dois quadros. O que permitiu a sua comparação e uma melhor compreensão da sua relação;
- O tratamento de *Isabel Maria Lourenço Affonso*. As escolhas feitas e problemas encontrados são descritos.
- A produção de uma tira substituta para a tira da pintura em falta. As soluções práticas desenvolvidas para superar este desafio tão incomum são descritas assim como o pensamento criativo e flexível necessário.

Uma vez que nem todos os materiais de preenchimento tradicionais se comportam bem, a um nível mecânico, com camadas muito finas ao longo de uma superfície muito larga (muitos são demasiado quebradiços), critérios estritos tiveram de ser aplicados para escolher o material adequado. O principal objectivo foi encontrar um material de preenchimento que permanecesse flexível e permitisse a aplicação de textura, de maneira a criar uma boa correspondência visual com a pintura. Análises e testes foram realizados para avaliar as propriedades físicas do material escolhido, BEVA® Gesso-P.

A criação bem sucedida de uma tira substituta resultou em duas publicações e uma apresentação:

Publicação pendente em *The Picture Restorer*, Leslie Carlyle, Raquel Marques, Isabel Pombo Cardoso and Sara Babo, "Creating a Textured Replacement Strip for the Missing Lower Portion of an Oil Portrait: Problem Solving and Practical Solutions".

Resumo aceite para apresentação e publicação em *International Meeting on Retouching of Cultural Heritage* (2RECH), Raquel Marques, Leslie Carlyle and Isabel Pombo Cardoso, "Textured Replacement Strip for a Missing Portion of a Portrait: Problem Solving and Practical Solutions".

Palavras-Chave: Retrato do século XIX; peça companheira; materiais e técnicas; tira substituta; textura da pintura; BEVA® Gesso-P; tratamento de Conservação/Restauro.





## ABSTRACT

This thesis focused on the study and treatment of a 19<sup>th</sup> century female portrait in oil from ECOMUSEU Municipal do Seixal, Portugal. The portrait, which depicts *Isabel Maria Lourenço Affonso* was in poor condition and a large strip of paint and canvas was missing (approximately 9cm by 66cm, almost 11% of the total surface area). The portrait is a companion piece to a male portrait (the relationship was established as part of this study), therefore a technical study of both paintings was considered essential to support the choices made during the treatment.

The project involved three main areas:

- The study of the history, condition, materials and techniques of both paintings. This allowed their comparison and understanding of their relationship;
- The treatment of *Isabel Maria Lourenço Affonso*. The choices made and problems encountered are described.
- The production of a replacement for the missing strip of paint and canvas. The practical solution developed to overcome such an unusual challenge is described along with the creative and flexible thinking required.

Because not all traditional infill materials cope well on a mechanical level with thin layers over a very large surface (many are too brittle), strict criteria had to be employed to choose the appropriate material. The primary goal was to find a fill which would remain flexible and be capable of accepting surface texture, such that there would be a good visual match with the painting. Analysis and testing was carried out to evaluate the physical properties of the fill material chosen, BEVA® Gesso-P.

The successful creation of the replacement strip has resulted in two publications and one presentation:

Publication pending in *The Picture Restorer*, Leslie Carlyle, Raquel Marques, Isabel Pombo Cardoso and Sara Babo, "Creating a Textured Replacement Strip for the Missing Lower Portion of an Oil Portrait: Problem Solving and Practical Solutions".

Abstract accepted for presentation and publication, *International Meeting on Retouching of Cultural Heritage* (2RECH), Raquel Marques, Leslie Carlyle and Isabel Pombo Cardoso, "Textured Replacement Strip for a Missing Portion of a Portrait: Problem Solving and Practical Solutions".

Keywords: 19<sup>th</sup> century portrait; companion piece; materials and techniques; replacement strip; painting texture; BEVA® Gesso-P; conservation/restoration treatment.



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## 1. INTRODUCTION

This work focuses on the portrait in oil of *Isabel Maria Lourenço Affonso* and its treatment. There is a second painting: the portrait of “*Domingos Affonso*”, which belongs to the same owner, matches in dimensions and has striking formal similarities. These paintings are considered companion pieces, therefore the materials and technique of the male portrait were also studied for comparison.

The study of these two paintings provided new and significant information regarding their history, period of execution and the probability that they were executed by the same artist. The relationship between the two is particularly important to justify treatment choices, such as the construction of a replacement strip for missing paint and canvas along the bottom of the female portrait to restore its original dimensions.

### 1.1. Description of the Painting

This work, a nineteenth century portrait on canvas, (artist unknown), belongs to Ecomuseu Municipal do Seixal, Portugal. The woman portrayed is “*Isabel Maria Lourenço Affonso*” [1] (Fig. 1). She is depicted sitting on a red chair, wearing a formal evening gown. The dress is of embossed green fabric, probably silk, with short sleeves that has a fitted bodice which ends in a pronounced point. The neckline is rounded and off the shoulder. The top of the dress is covered by a white/cream lace cape (likely bobbin-lace) with floral and geometric motifs. Garnishing the neckline is a pinkish fabric strip with a white floral design. The body of the dress would likely have inside “stays” to tighten and keep its shape. The voluminous skirt, in a green fabric with a transparent brown design, is pleated where it meets the bodice, and would likely have held its shape with the help of an under garment (crinoline).

The figure’s hair is parted in the centre, and pulled back while covering the ears. There appears to be evidence at the crown of the head of a ribbon or hair ornament holding the hair up at the back.



**Figure 1** - *Isabel Maria Lourenço Affonso* portrait, normal light photograph before treatment.

In terms of jewellery the figure wears a brooch in gold and precious stones ornamenting the neckline, three bracelets and two rings.<sup>1</sup>

This painting along with the male portrait, was donated to the Ecomuseu collection in 2009. Although they had been in the donor family for generations there was little historical information provided. Both had been given a full restoration in the past, possibly while in England as there is a label on both stretchers from a British removal firm (Woodbridge & Co. Ltd) (Fig. II.1).

## **1.2. Historical Context**

According to José Mattoso, in Portugal, the bourgeoisie construction of the intimacy notion, followed the rules imposed by the culture of appearance, which was translated individually in body care and fashion submission. It is specially the personal presentation – in particular the costume, hair and body silhouette – where this is manifest [8]. After the establishment of the Liberal Regime, in 1820, portraits became a common instrument of the bourgeoisie to show its new political and social prestige. To be portrayed was primarily a social phenomenon more than an artistic one [51].

An historical investigation was made in an attempt to understand who *Isabel Maria Lourenço Affonso* was and why she and the male companion piece are historically important for this regional museum, as well as to assist in the treatment.

### **1.2.1. The Family**

According to the Inventory of the Ecomuseu Municipal do Seixal [1] the portrait was likely of *Isabel Maria Lourenço Affonso*. She was the daughter of *João Luís Lourenço*<sup>2</sup> who bought the Tide Mill of Corroios in 1836 [2,3] and the wife of *Domingos Affonso* who inherited the Tide Mill after the death of her father. The family owned the mill until 1958<sup>3</sup>, hence their importance to the museum (which now owns the mill) and why the paintings were donated by a descendant. That the two sitters were husband and wife was verified by archival information<sup>4</sup> [4] discovered during the investigation in this thesis of the historical context of the portraits.

Documentary research [2,4,5,6,7] made it possible to build an almost complete genealogical tree of the family (Appendix IV), up to the point of the donor (Teresa Newbery). As a result the Ecomuseu now has a better understanding of the family, and its influence in the region.

Isabel Maria's husband, *Domingos Affonso*, was an influential person, mentioned as a merchant, city councilman<sup>3</sup> and also a Vice Consul of the USA<sup>3</sup>. The latter was confirmed in the letter portrayed in his portrait (Fig. III.1). A spectral imaging instrument<sup>5</sup> which allowed analysis of the painting at different

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<sup>1</sup> The formal description of the costume was kindly discussed in Portuguese by Dr. Xénia Ribeiro from the National Museum of Costume and Fashion, in a personal communication.

<sup>2</sup> A portrait of *João Luís Lourenço*, which also belongs to the museum, was previously treated by Joana Devesa, Masters Student, 2012.

<sup>3</sup> Information available in *Moinho de Maré de Corroios* exposition.

<sup>4</sup> Reference of a marriage between *Domingos Affonso* and D. *Isabel Maria Lourenço*, Lisbon, Paróquia de São Paulo on 3 of May of 1845.[4]

<sup>5</sup> Demonstration by Dr. Vassilis Papadakis, of the IRIS-II Spectral Imaging instrument, during SYDDARTA workshop at FCT-UNL, January 21<sup>st</sup> 2014.

wavelengths was used at 550nm where it was possible to achieve significant improvement in legibility of the script. The script was then enhanced digitally (by writing on top to clarify the letters) (Fig. III.2).

### **1.2.2. Dating the Costumes**

Neither painting is dated, and although the museum inventory states that they were likely made in the second or third quarter of the 19<sup>th</sup> century [1], a significant part of this historical investigation was to try to date the paintings by their costumes. Based on an interview with Dr. Xénia Ribeiro and Dr. Ângela Valério<sup>1</sup>, specific characteristics such as: the off the shoulder neckline; the lace cape with a floral motif; the fitted bodice ending in a pronounced point; the voluminous pleated skirt and the hair pulled back covering the ears, helped to narrow down the portrait to within a 10 years period (approximately 1845 to 1855), which is in line with the documentary sources [9]. This analysis does not mean that the sitter could not have used this costume in later years. The interview with the costume specialists was extremely helpful not only as a method of dating but also to increase the understanding and knowledge of this period in fashion and for imagining what could be missing in the painting, such as a possible fan which the sitter could have been holding as this was very common in similar portraits of this period.

Even though the male portrait was also evaluated in terms of costume it is more difficult to establish a specific time period because differences in male fashion are less accentuated. However, while the costume of the male does not add to the dating of the female's costume it does not contradict it and helps to establish a range between 1840-1860 (see Appendix III), which can still be narrowed, if after the cleaning of *Domingos Affonso* portrait, more details from the costume appear.



## **2. CONDITION REPORT**

Overall the portrait of *Isabel Maria Lourenço Affonso* presented structural and aesthetic problems associated with water damage and exposure to high humidity, such as mould growth on the stretcher, canvas and painting, as well as blanching in the image (see Fig. II.2, II.3, II.6, II.10, II.11). The most significant problem is the missing strip of paint and canvas along the bottom of the painting (approximately 9 cm by 66 cm) which represents approximately 11% of the image. It appears to have been cut off as the edge indicates a clean cut (which is uneven and on an angle). There was also an active flaking problem (at the interface of paint and ground and at the interface of the ground and the canvas) mainly in the lower part of the painting associated with the extreme water damage. Due to the risk of losing fragile paint it was impossible to place the painting vertically until flakes were consolidated. The painting had previously been lined. The lining fabric was weak and deteriorated and had detached from the stretcher along the bottom edge.

### **2.1. Auxiliary Support: Stretcher**

The auxiliary support is a wooden stretcher (soft wood, probably pine) measuring approximately 86cm x 66cm, with a Simple Mortise & Tenon corner construction (2 keys with 2 blind slots). It has a horizontal cross bar in the centre. All 10 keys are present. The stretcher likely dates from the lining, since one of the original tacking margins (right side) is visible in the x-radiograph (Fig. I.7), indicating that the painting had originally smaller dimensions (see chapter 2.3). All three paintings<sup>6</sup> from the mill have a paper shipping label on the stretcher from a British transport company “WOODBIDGE & Co. Ltd.”, with the name Newbery (the donor’s family) (Fig. II.1).

This stretcher was in poor condition with evidence of water damage (tide lines), mould growth and exit holes from a previous infestation of wood boring insects (Fig. II.2). It was also slightly warped and split in the upper mortise (left lower side). The structural instability and warping made it necessary to replace this stretcher.

### **2.2. Previous Treatment: Lining**

The painting had been lined in the past (along with aesthetic treatment: infills and inpainting, see Fig. V.1); work likely done by a professional given its high quality. Lining is the process of attaching a new support to the back of the original painting to give it increased strength [10].

In this case the new support was a single piece of fabric with a plain weave<sup>7</sup> and comparatively thicker threads and a lower average thread count (15 vertical and 16 horizontal threads per cm<sup>2</sup>) than the original canvas (25 vertical and 26 horizontal threads per cm<sup>2</sup>).

The lining canvas fibre was identified by observation in the Optical Microscope (OM) as bast fibre (probably flax or hemp), full analysis is given in Appendix VI.4.

The lining canvas showed evidence of being in direct contact with water as there was a dark tide line visible at the bottom (Fig. II.2, VII.3). The existence of the lining fabric at the bottom of the painting where the original paint and canvas are missing, gives a hint of what may have occurred. It is likely that the water dissolved the glue-paste adhesive and the wet painting, now detached from the lining canvas, began to

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<sup>6</sup> This paper label also exists in the stretchers of *Domingos Affonso* and *João Luiz Lourenço*.

<sup>7</sup> Plain or tabby weave, the simplest crisscross pattern, where the threads go under and across each other one at a time.

distort by curling upwards. Perhaps in an effort to stop it from completely delaminating from its lining and presumably to halt the distortion and paint loss, the painting was simply cut off in an uneven line across the bottom.

The lining adhesive was analysed by Polarised Light Microscopy (PLM) and  $\mu$ -FTIR (see Appendix VI.6 – Old lining adhesive analysis). In the  $\mu$ -FTIR spectra characteristic bands of a protein-based adhesive such as animal glue and bands from a polysaccharide such as starch or gum were present (Fig. VI.15). These results support the idea that the lining was made with a glue-starch based adhesive, which indicates a treatment involving heat, moisture and pressure [11, 12]. These three factors bear some disadvantages that can cause damage to the painting, for example the flattening of brushstrokes and impasto caused by prolonged and excessive pressure and heat, as appears to have happened in the jewellery impasto (Fig. II.12).

Regarding its condition, the lining canvas was significantly deteriorated and had lost its function of keeping the original canvas reinforced and under tension. Apart from the tide line and mould growth in the bottom area, the fabric was torn, and along the sides, the oxidized metal tacks had resulted in fabric loss (Fig. II.3, II.10). Since the fabric had come loose from the stretcher, in some areas, it was considerably slack creating stretcher-bar creases and depressions in the painting (Fig. II.11). The adhesive was also in poor condition as it was fairly easy to separate both fabrics with mechanical action (apart from the centre that proved to be well adhered, see below). There were occasional insect exit holes originating in the stretcher which included the fabric along the tacking margins. The previous restorer had applied infill putty with a line of black paint on top along the outside edges of the image, presumably to neaten the raw cut edges where the tacking margins had been removed and making a transition between the painting and the tacking margins of the lining canvas.

### **2.3. Original Support: Fabric**

The original support is a single piece of fabric with a plain weave. The thin threads and the high average thread count (25 vertical and 26 horizontal threads per cm<sup>2</sup>) make this fabric a very fine canvas.

The fabric is composed of bast fibres, likely linen, based on observations with the Optical Microscope (OM) of a fibre in both longitudinal view under polarized light and in cross-section (see Appendix VI.4).

The painting is approximately 77cm by 65cm. The original tacking margins appeared to have been removed, but closer observation of the x-radiograph (Fig. I.7) showed an original tacking margin from the right side of the painting. This is based on the evidence of holes with similar distances that resemble tacking holes, which we can see along that margin as well as the line of broken paint and exposed canvas indicating the previous turn-over edge.

The fabric is generally in good condition despite the rough and uneven cut in the lower margin and the overall loss of tension. In several places the paint projects beyond the cut area (see detail Fig. II.5). Apart from slight stretcher-bar creases caused by the lack of tension (mentioned above) deformations in the painting are not pronounced. As noted above the lining adhesive was deteriorated in areas affected by water and in some places the lining canvas had detached from the original. The out of plane distortions, mainly around the right side (Fig. II.8, II.9), could have occurred due to the movement caused by the adhesive swelling and dissolving, and the response of the canvas to high levels of humidity. In places



distortions in the fabric have resulted in the loss of paint and ground where the aged brittle paint could not conform to the movement.

#### **2.4. Preparation Layers**

Grounds have the primary function of preparing the canvas surface for the application of paint; they can enhance or reduce texture, determine the painting's tonality and be more or less absorbent according to the properties desired [12,13]

The ground is a light white-beige colour. It appears to be evenly applied to the canvas (a tightly woven fabric) making the fabric texture imperceptible. Although not pronounced there appear to be application marks (brushstrokes and streaks) visible in the x-radiograph, which could be related to the ground application.

The distribution of the preparation layers can sometimes lead to the distinction between a commercial ground or a ground applied by the artist/atelier. In this case, with the original tacking margin visible in the x-radiograph, it is possible to see that the ground extended onto the edges of the tacking margin, suggesting that it could have been a commercial ground. During the nineteenth century ground application was often done by commercial manufactures and light coloured grounds were preferred [12,13].

Regarding the original tacking margin visible in the x-radiograph, close observation shows paint loss at the turn over edge with a pattern associated with aged brittle paint, indicating that this was likely a later alteration and not something done by the artist during the painting's execution.

Overall the ground seems to be in good condition, with the exception of damages to the paint which includes the ground. In these areas the ground is only partially lost, leaving some areas of intact ground visible (Fig. II.7). There are also some local paint and ground losses where the canvas is exposed (see Fig. V.1).

Analyses were performed to characterize the ground layers. With cross-sections of the paint and ground composite, observations were made with OM and Electron Scanning Microscopy with Energy Dispersive X-ray Spectroscopy (SEM-EDX). The latter provided information on stratigraphy and morphological features. Cross-sections S8 and S9 provided the most complete stratigraphy showing two ground layers (Fig. VI.9, VI.10).

In SEM-EDX, the lower layer contained Calcium (Ca) and Sulphur (S) which indicates a layer with a calcium sulfate product. This result and presence of gypsum (calcium sulfate dihydrated,  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) was confirmed by  $\mu$ -Raman and  $\mu$ -FTIR from a ground sample removed from the interstices of the canvas (see Table VI.2 and appendix VI.6 – Ground analysis).

The second ground layer, immediately below the paint layers, in all the analyses performed consistently revealed a mixture of lead white ( $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$ ) and barium sulfate ( $\text{BaSO}_4$ ) with an oil binder (see Table VI.2 and VI.6 – Ground analysis).

#### **2.5. Pictorial Layers**

The paint is thinly applied, with only a few areas of impasto (mainly in the jewellery) and some buttery textured brushstrokes in the flesh tones and costume. It is more transparent in the dark colours than in the lighter ones. The layered application is very noticeable in the face and can be confirmed by the cross-section stratigraphy (see Fig. VI.2, VI.4, VI.9, VI.10).

Throughout the painting's surface it is possible to see small round shaped protrusions that influence the painting's texture. In some areas these protrusions no longer have paint on top (these appear as small white dots) (Fig. II.13, II.14). As confirmed by observation of cross-sections these protrusions (transparent to whitish in normal light and fluorescing in UV light) have characteristics attributed to an identified problem, the metal soap aggregates [14] (Fig. VI.5, VI.6). The same problem is present in the other two paintings and was studied by Devesa for her Masters thesis [3].

Overall the painting present significant mechanical cracks that can be easily recognized in raking light (Fig. II.8, II.9) and in some areas the cracks have lifting areas (slight cupping) that culminate in small losses at the edge, a problem visible throughout the surface. There are also abrasions along the edges of the painting (some appear associated with a frame), elsewhere local scratches and abrasions (Fig. V.1).

The paint in the portrait of *Isabel Maria* was examined by Micro Energy Dispersive X-ray Fluorescence ( $\mu$ -EDXRF) and cross-sections were analysed by OM, SEM and  $\mu$ -Raman providing valuable complementary information on the painting technique and materials (pigments), while micro samples analysed by  $\mu$ -FTIR identified materials (binder, pigments and varnish).

As noted above for the ground, the binder for the paint was also identified as oil. The pigments identified were: lead white, barium sulfate, vermilion, iron oxides (goethite and hematite) carbon-based pigment (carbon black), ultramarine blue (probably the synthetic form), Prussian blue, orpiment, emerald green, and probably terre-verte, Naples yellow and a red lake pigment (likely madder). Analysis are summarized in Table VI.3). All the pigments found were available and in use in the 19<sup>th</sup> century.

## **2.6. Surface Coating: Varnish**

The main functions of a varnish are to even out gloss, saturate the colours and to act as a protective layer for the paint [11,13,15] .

There is a varnish layer coating the painting surface, visible in normal light by the degree of yellowing and in Ultraviolet (UV) light by the greenish fluorescence which suggests a natural resin (Fig. I.5) [12]. All cross-sections show evidence (even if just partial) of a thin varnish layer, except cross-sections S7, S8 and S9 (from the bottom part – green dress) which present a thick broken up layer likely due to blanching in this section of the painting.

The varnish was analyzed by  $\mu$ -FTIR, confirming the presence of a natural resin (excretions from certain plants or insects [16]). Although the spectrum can be attributed to a natural resin from a tree source, attributed to mastic or dammar, it was not possible to clearly distinguish between them. Both mastic and dammar were extensively used as picture varnishes, and belong to the category of spirit varnishes [13,15,16,17]. They are triterpenoid resins, which means they consist of cyclic isoprenoid compounds with 30 carbon atoms [15]. This cyclic ring structure produces distinct bands, as observed in the spectra (Fig. VI.18).

Overall the varnish is in poor condition due to the significant yellowing (mainly evident in lighter areas such as flesh tones) and blanching in the bottom margin resulting from water damage (Fig. II.6). The dirty and discoloured varnish layer distorts the spatial relationship and colour balance of the painting, and in blanched areas it is opaque obscuring the image completely. Overall it has an uneven satin gloss.

### **2.7. “Domingos Affonso” Condition Summary**

Like the portrait of Isabel Maria, the portrait of *Domingos Affonso* also has problems associated with water damage and high humidity which have resulted in mould growth, blanching and damage to the paint and stretcher (Fig. III.1, see Appendix III, for a brief summary of its condition).



### 3.CHARACTERIZATION OF MATERIALS AND TECHNIQUES FROM BOTH PAINTINGS

Both portraits were compared and studied in terms of style, technique and materials to try to assess whether or not they were made by the same artist and within the same time period.

#### 3.1. Stylistic Analysis

The two paintings present striking similarities, both formally and aesthetically. They appear to be companion pieces, perhaps made shortly after their wedding in 1845 [4].

Formally, both figures have the same proportions and present a formal position. While she is sited on a red chair, he could be seated or standing in front of a red chair, each with the head three quarters to one side (Fig. 2). The figures' subtle lines and lighter colour tones contrast against an empty dark background, creating a simple composition focused only on the individuals portrayed.

Regarding the aesthetic details, it is in the face contours: the eyes, nose, lips, chin and cheekbones where the resemblance between the two portraits is most noticeable. In these areas the highlights and shadows are constructed in a very similar way, evoking the same artistic hand (Fig. II.15: 1,2,3,4,5,6). Also the hands which are usually very indicative of the artist technique, appear formulaic with the fingers showing a distinct taper (thicker in the base, thinner in the end) and in the shape of the nails [pers. comm. Rita Macedo, Setembro 2014].

There could be more aspects to consider and describe, but at this stage and mainly without further cleaning of the male portrait it is very hard to draw more common points.

As previously noted (chapter 1.2.2), the figures' costumes are in line with the assumption that these portraits were made in the same period. In terms of accessories used by the sitters: while *Domingos* proudly holds a paper (similar to nowadays business card) with one hand (Fig. 2, III.1, III.2); *Isabel Maria* rests one arm on the chair and the other on her lap (possibly holding something, likely a fan).



**Figure 2** - *Isabel and Domingos Affonso* portraits, normal light photograph, before treatment.

### 3.2. Painting Technique

Both paintings present the same method of paint application in layers. The technique was often described throughout the 18<sup>th</sup> and 19<sup>th</sup> century instruction books on oil painting in Britain and Portugal, and was based on observation from the “old masters” technique [13,18, 19]. This method consisted of painting in separate stages, allowing each layer to dry first. As described by Bardwell in 1756, painting involved three main stages: the first painting or dead colouring, the second painting and the third or last painting [13,18]. The painting should be painted with transparent paint in the shadows and opaque paint in the lights [13,19,20].

The area where the layering technique is most evident, is in the faces of the sitters. Both present a beige toned layer over which pinkish and brown shades are used to build the features: chin, cheeks, nose, eyelids and eyes. In both sitters highlights appear as small touches of white, for example, in the point of the nose, around the mouth, and near the pupils in the eyes (Fig. 3, Il.15:1, 2).



**Figure 3** - Detail of *Isabel* and *Domingos Affonso* faces, normal light photography

The similar construction in both paintings is also clear in the jewellery (her brooch and his shirt button) where the paint is thicker and small dots of impasto are used.

Cross-sections from both paintings confirmed that the layer stratigraphy was similar. Most cross-sections show only two paint layers, although in some cases a third layer was visible (mainly distinguishable with UV light). There are cross-sections with four layers, particularly the ones from background areas, but the fourth layer appears to be related to the previous treatment. This is easily recognisable in S6 (female portrait) where the top layer is present on the left side of the sample (Fig. VI.7), covering a crack in the paint composite which indicates it was applied after the painting exhibited brittle fracture, strongly suggesting the presence of overpaint. This top layer has a completely different appearance with pigment particles which are very much finer than in the underlayers.

Regarding the particle morphology, in both paintings it is possible to observe layers made with a mixture of different pigments, with variable particle sizes. It is also evident that the paintings were constructed with the figure placed in a reserve, since cross-sections from the hands (flesh paint) which are laying in the lap of each figure do not have a darker layer underneath (green for the female and black for the male).

As noted above X-radiographs of both paintings (Fig. I.7, I.8) show that the dimensions were adjusted after the paint had become brittle, suggesting this occurred during the previous lining. The remaining evidence for the original dimensions of both is not complete, due to missing tacking margins, but judging from the images it is likely they were always a similar size and in proportion to each other. Thus reinforcing the decision to restore the female portrait to the previous dimensions before the bottom strip was removed.

### 3.3. Analysis of Materials

After careful analyses of the materials in both portraits a comparison between them was then possible. The male portrait was examined with  $\mu$ -EDXRF and cross-sections were analysed with OM, SEM,  $\mu$ -Raman and  $\mu$ -FTIR. A table of the pigments identified in the ground and paint layers is given in Appendix, Table VI.4 and VI.5, respectively.

Starting with the support, the original canvas in the male portrait is a single piece with plain weave. The fibres were identified as bast fibres (likely linen or hemp) and the fabric has a thread count of 14 vertical and 14 horizontal threads per cm<sup>2</sup> (accessed through the X-ray image – using the x-ray digital system scale to determine the cm<sup>2</sup> area – since the painting is still lined and there is no access to the original canvas). Like the female portrait, the male portrait shows evidences of original tacking margins in the x-radiograph, but this time in two locations – left and bottom (Fig. I.8). Evidence of brittle fracture in the paint in the turn over edge and tacking margins indicates that the size of male portrait was also changed well after it was painted. The ground continues through the original tacking margins, suggesting the possibility of a commercial canvas.

Regarding the preparatory layers on *Domingos Affonso's* portrait, in the bottom of cross-section S3 it was possible to identify through SEM and  $\mu$ -Raman evidence of calcium carbonate (CaCO<sub>3</sub>). No binder analysis was performed on S3.

While observation with OM showed a single thick white ground in all cross-sections, analysis with SEM revealed what appear to be two layers (more samples are needed to confirm this layer distinction since it was not consistent throughout the samples analysed). The layer(s) was composed of lead white (2PbCO<sub>3</sub>.Pb(OH)<sub>2</sub>) and barium sulfate (BaSO<sub>4</sub>) (see Table VI.4) in an oil binder.

The information so far is already sufficient to state that the original supports of the female and male portraits are different, both regarding the fabric (thread count) and the ground. While the female shows evidence of a gypsum layer and then a layer of lead white and barium sulfate, the male portrait has a bottom layer of calcium carbonate followed by lead white and barium sulfate.

This indicates that they do not belong to the same roll of prepared canvas - which might have been expected for a pair of portraits where the commercially prepared canvas was purchased at the same time.

Concerning the materials in the paint layers, the binder is oil as confirmed by  $\mu$ -FTIR, and the pigments identified were: lead white, barium sulfate, vermilion, iron oxides (goethite and hematite), a carbon-based pigment (carbon black), Prussian blue and a red lake (likely madder) (see Table VI.5). All were encountered in the female portrait, which suggests the same palette of colours.

Cross-sections also reveal restoration layers in both portraits which match in appearance, taken in combination with the structural treatment this strongly suggests a restoration done in the same period, likely in the same place.

While this study cannot categorically confirm that the paintings were done by the same artist, the strong visual evidence in terms of stylistic elements, and the use of the same palette strongly suggests the same hand.





## **4. THE REPLACEMENT STRIP: INFILL MATERIALS**

### **4.1. Introduction**

As noted above since the female portrait is a companion piece, it was considered essential to restore it to its original dimensions when last restored. Therefore a principal part of the treatment was to create a strip of material to replace the missing canvas and paint.

The intention was to reline the painting and to incorporate the missing strip during the lining. It was necessary to identify a suitable archival quality material for the replacement strip that would match the physical characteristics of the painting and its thickness (approximately 0.1 cm including the painting and canvas). This would require a uniform thin flexible layer of a slightly rubbery quality which ruled out a range of infill materials which would be too stiff and brittle in the thickness required. Another goal was to create a surface texture echoing the painting's such that the strip could be convincingly reintegrated. The crafting of the replacement strip and the individual steps taken are summarized below (chapter 5.10) and are further detailed in an article submitted for publication (attached in DVD) [50]. What follows is a discussion of the infill material chosen, the options available and the testing of the infill material since the portrait will be returned to an uncontrolled environment.

### **The selection of infill material**

The selection of infill material involved creating a list of possibilities available (see Appendix IX.2, Table IX.2), then checking them against the required criteria: an archival quality material compatible with the original materials (chemically, physically and mechanically); capable of receiving an impression of texture; able to be thinly applied to match the thickness of the painting (approximately 0.1cm); able to be easily removed from the texture mould; with long-term flexibility and stability. Ideally this material could be cast in a strip that could be incorporated during the lining.

With that in mind, the system used in SRAL<sup>8</sup> was considered, where BEVA® 371 is mixed with kaolin forming a flexible infill material - referred to here as Modified BEVA® 371 - capable of receiving texture by heating through a silicone mould. Two other possibilities were BEVA® Gesso-P or Wax-Resin with chalk and pigments. Although these materials were all flexible, Wax-resin was rejected due to the unpredictability of its behaviour in high ambient conditions. Therefore the BEVA® options were the more favourable choices.

Modified BEVA® 371 could not be produced in a uniformly thin strip of the required dimensions due to a lack of suitable equipment for heating such a large piece. Therefore the BEVA® Gesso-P was investigated since it had the potential to provide a flexible, durable thin film which would accept texture due to its heat sensitivity.

### **4.2. Beva Gesso**

There are two types of BEVA® Gesso: BEVA® Gesso-P fine-grained and BEVA® Gesso-V medium-grained [21]. BEVA® Gesso-P (BGP) (see Suppliers), chosen for this treatment because it was fine

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<sup>8</sup> First demonstrated by Petria Noble, Head of Conservation, Mauritshuis, The Hague. This method was developed at the Stichting Restauratie Atelier Limburg (SRAL), Maastricht. In 2013 Kate Seymour, Head of Education at SRAL, held a workshop to instruct the use of this method which was originally developed by one of SRAL's senior painting conservators, Jos van Och.

grained and composed of “a compressible, inert mineral powder, oxidation inhibitors, UV stabilizers, a buffer to remain a non-acidic pH and BEVA® resins” [22, 23].

It appeared to have great potential to fulfil the necessary criteria for this particular problem<sup>9</sup>. From all of the characteristics of BGP listed on the “BEVA® Gesso Description and Instructions for Use” from Talas [23] the most relevant for this specific case were:

- Its stability (grade A material according to Dr. Feller );
- Its handling properties and final appearance can be adjusted (for example: adding solvent to adjust working time or casting to reproduce surface topography);
- It can be textured;
- It is a highly elastic material (that can follow the movements in the paint system caused by environmental fluctuations).

BEVA® Gesso-P was analysed using  $\mu$ -FTIR,  $\mu$ -Raman, SEM-EDX and  $\mu$ -EDXRF. These methods confirmed the presence of the ‘BEVA® resins’, however only partial confirmation of the filler was possible (calcium carbonate and aluminium, silicon, oxygen and sodium were found). See full analysis in Appendix IX.3.

It is expected that BGP should be a very durable material since it consists primarily of BEVA® 371, which has been extensively studied (Down, Ploeger, De la Rie, McGlinchey, etc). It has also been investigated in terms of its photo-chemical stability [25,26,27] and changes in solubility [26] where it presents greater concerns. While solubility is not a significant issue since the strip is independent of the painting, photo-chemically induced colour change could present a problem in the long term, limiting the lifetime of the replacement strip (see Conclusions).

A series of empirical tests to evaluate the working properties and suitability of BGP were carried out. Knowledge of its behaviour, appearance, strength, adhesion, and ability to accept a textured surface was gained through tests and trials revealing crucial information that shaped the procedure for creating the replacement strip. For example, it was quickly discovered that BGP will reproduce the surface of the material to which it is applied, which made it possible to cast a film of BGP directly from the textured silicone mould (rather than applying the texture with heat after the infill is dried as done in the SRAL MB technique) [51]. While BGP directly from the can could not be applied in a continuous thin even film over the textured silicone mould (it is a paste-like material), it was possible to dilute it with solvent to make it fluid enough to be spread with a scraper (the draw-down method). To avoid cracking and to control film thickness, it was necessary to apply it in a series of thin layers allowing each to dry between applications. The solvent choice also involved various trials with different solvents (such as: Toluene, Xylene, Shellsol D40, Shellsol A, Shellsol T and White Spirits) where the percentage of aromatics and the evaporation rate were key factors (Table IX.3).

With good results for reproducing surface texture and producing a thin even film of the required thickness, further testing with mechanical stress measurements was carried out to evaluate its physical properties when subjected to forces that induce stress. “Stress is one of the known contributors to the structural failure of polymeric films” [28] also “the development of stress is involved in practically all stages

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<sup>9</sup> Laura Fuster-López, in her PhD thesis on infill materials (2006, Appendix XLVIII and X) [24] described BGP as having “extremely plastic behaviour”, being “very soft and weak,” with excessive “stiffness, adhesive strength, [and] cohesive strength,” and noted that it was difficult in application. For this application these findings were not corroborated.

of coating life (film formation, exposure to various climatic conditions), its measurement is essential for a better understanding of coating behaviour.” [29].

#### **4.2.1. Stainless Steel Gauges**

Two different tests with flexible stainless steel gauges were undertaken (300 Series stainless steel thickness gage: 12.7mm width x 305mm length x 0.127mm thick, from Precision Brand Products) [28] The principle behind these tests is extensively described elsewhere [28,29,30], but in brief, it is based on the fact that if “a paint applied on a flexible substrate is under stress, the coated substrate will curve in the direction which relieves the stress. Since the deflection can be measured (...) the internal stress can be calculated.” [29,30]. Therefore, observation of the curvature can provide qualitative data on the stress levels developed (higher curvature means higher stress).

The first test consisted of applying onto the gauges the same thickness and amount of BGP used for the replacement strip and measuring qualitatively the curvature which resulted after application and after drying (Fig. 4 top). This measured the ‘internal stress caused by film formation’<sup>10</sup>.

Because the painting will be stored in an uncontrolled environment with high relative humidity (RH) (Appendix X), a second test, to assess the response of BGP to RH changes was performed. Gauges coated with BGP, were exposed to weekly cycles of high RH levels (<95%) followed by low RH (>25%), for three months.

The test was performed in a closed plastic box with the gauges hanging vertically, attached at one end. Moisture was introduced by an Ultrasonic Humidifier (PIFCO Health, Product No. 1077) followed by the introduction of silica gel - Orange Silica gel (2.0 – 6.0 mm) LabChem (Lisboa, Portugal). Controls were hung in the room near the box. Two data logger systems measuring RH and temperature were used: one that allowed real time (by the second) readings<sup>11</sup> and another that recorded data at 30 minute intervals<sup>12</sup>. The curvature of the gauges was measured by photographing them against millimetric paper. This measurement provided qualitative data of the external stress developed by the BGP coating, as a result of RH fluctuations – i.e. hygroscopic stress.

The results indicate that BGP developed virtually no stress during film formation or when submitted to dramatic RH fluctuations, as no curvature of the composite was observed (Fig. 4 bottom). Also it is important to mention that no cracks were observed in the BGP film (before or after the RH fluctuations).

These important results led to the conclusion that BGP was an appropriate choice as an infill material for this treatment, since it provides suitable mechanical behaviour (within the testing period, further investigation with aged BGP would be needed to confirm this, however the dominant material, BEVA® 371 which has been tested for long-term durability, shows good stability, see above).

In addition an experiment is underway to establish if any dimensional changes occur in a BGP strip lined onto the lining fabric with the Mist lining technique when the whole strip is exposed to RH fluctuations. The strip of BGP lined with the *Mist Lining* technique has been stretched onto a wooden support. Future

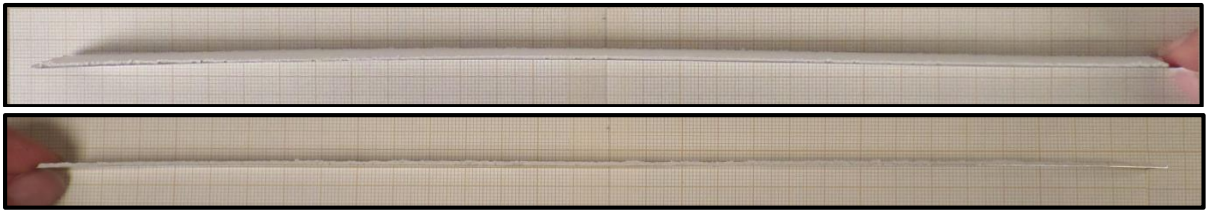
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<sup>10</sup> “During film formation and regardless of the mechanism involved (evaporation of solvent (...), in almost all cases the coating tends to contract. If this contraction is prevented by coating adhesion to its substrate and/or the mobility of macromolecular segments is hindered, a tensile stress will develop in the coating.” [29]

<sup>11</sup> Arduino UNO R3 microcontroller board with DHT22 Temperature and Humidity Sensor assembled and programmed by Jeremie de Seabra (MSc in ECE) specifically for this project.

<sup>12</sup> LASCAR Data logger, USB Easylogger Software. <http://www.lascarelectronics.com/data-logger/easylogger-software.php>

tests could be made to evaluate other variables, such as temperature fluctuations, and different thicknesses of BGP.



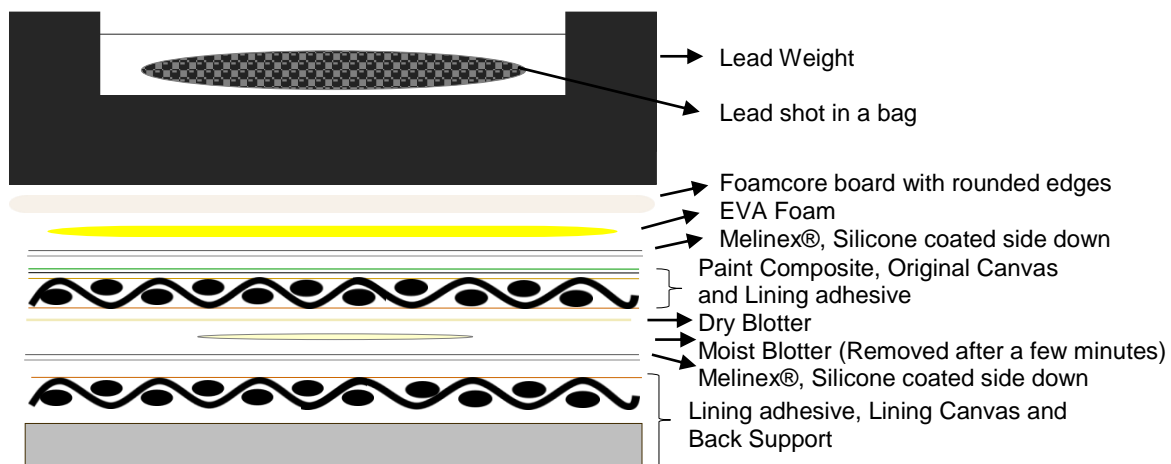
**Figure 4** - Gauge curvature after application and drying of BGP layers (top). Same gauge with BGP after 3 months of RH cycles (bottom). Almost no curvature is observed in either image.

## 5.TREATMENT REPORT

### 5.1. Local Flattening

Pronounced deformations in the paint and original canvas near the sitter's right hand required flattening. Performing this step before facing ensured better conformation of the facing tissue. Where paint was delaminating, it was necessary to consolidate prior to placing the painting face down to avoid further losses (flaking was localised in a relatively minor area, see Fig. V.1).

Since the lining adhesion was severely degraded it was possible to separate the two canvases with a palette knife along the margins (this also entailed removing the black painted putty along the edges from the previous treatment). In the bottom right margin the separation was achieved to a point slightly above the damaged area which required flattening. Separation between canvas and lining fabric was important as it allowed the construction of a system to introduce moisture prior to flattening without the risk of reactivating the lining adhesive.



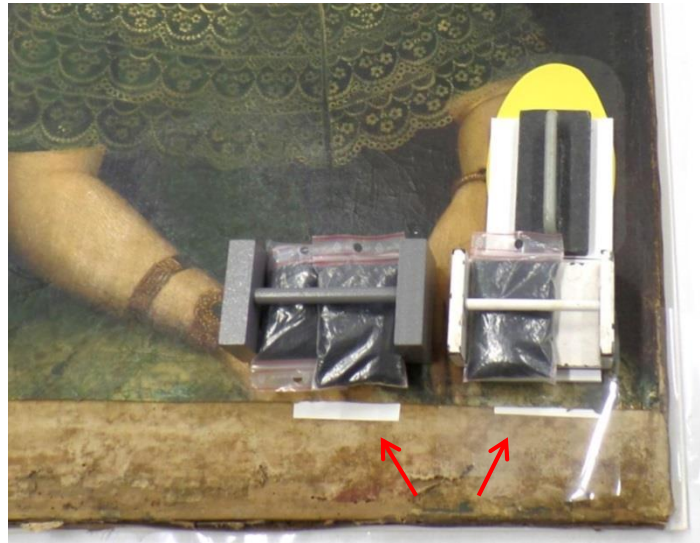
**Figure 5** - Diagram of the system used during the flattening.

After assuring that the painting was well supported at the back (allowing an even distribution of the weight which was applied from the top) and placing a piece of silicone coated Melinex® (side down) between the original and lining canvas, the flattening was performed as illustrated in Fig. 5.

Blotting paper cut to the size of the area to be flattened was sprayed with distilled water and left inside a sheet of Melinex® sealed with weights for at least 30 minutes to 1 hour (according to its dimension) until the moisture was distributed uniformly through the blotter.

In order to locate the layers of dry and wet blotters underneath the painting in areas requiring flattening, a Melinex template was constructed. First a piece of thick Melinex® was placed on top of the painting and a template was drawn with a permanent felt pen to mark the position where the wet blotter would be placed, and a line drawn at the edge of the painting for registering the location of the Melinex.

The Melinex® was then reversed and the lines copied again in permanent marker on the underside. After, it was placed face up and the first set of lines removed with 100% ethanol, leaving the second set on the underside (this ensures that permanent marker ink cannot be transferred to canvas at the back of painting). The wet blotter was held in place under the dry blotter using adhesive tape. The blotters were then introduced under the painting for 5 minutes. During that time, a piece of Melinex® and light weights were placed on top. The response to the moisture treatment was evaluated regularly by lightly tapping in the area to assess its degree of resistance to movement, and to “feel” the surface coldness/humidity (if the moisture was travelling fast and spreading around). When the deformation in the paint and canvas felt flexible (5-7 minutes), the two blotters (dry and wet) were replaced by a dry blotter, and a system of weights and cushioning material was applied on top (Fig. 5). The process was repeated for all the areas requiring flattening (Fig. 6). Overall the treatment was successful although some areas were still a little bit elevated, however since the problem was also related to the original fabric it was decided to try to flatten them further during consolidation (introducing an adhesive to hold it in place) or if necessary to wait until removal of the lining adhesive to see whether or not old glue residues were influencing the distortions.



**Figure 6** - Weights applied locally to flatten the paint. The arrows point to the Melinex® and Blotting paper under the painting.

## **5.2. Consolidation**

As noted in Chapter 2, the painting was in a very fragile condition urgently in need of consolidation. An initial consolidation had been performed by Joana Teixeira, using a brush to introduce BEVA® 371 (original formula) dissolved in white spirits (approximately 1:1, until the desired flow properties). Afterwards it was possible to perform X-radiography in the vertical position.

Examination during the current treatment revealed areas of concern where there was still active flaking and tenting paint – mostly at a “micro” scale (1 to 2mm in size) and likely overlooked compared to the easily observable instability at the bottom edge which had already been consolidated.

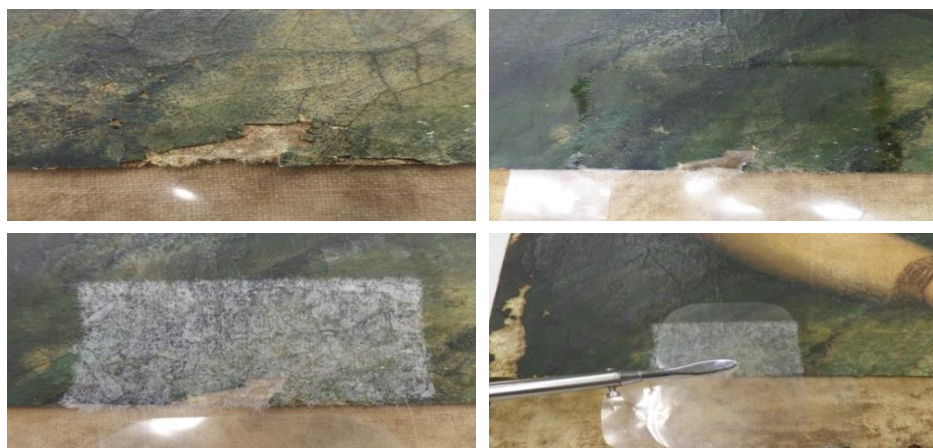
BEVA® 371b<sup>13</sup> (see Suppliers) was chosen to consolidate the micro instability as it tested safe for the paint and was considered the appropriated adhesive especially in relation to the future where it would be subject to uncontrolled environmental conditions while in storage and on display (an aqueous based adhesive could easily fail with severe RH fluctuations (Appendix X)). As established above, BEVA® 371b is a “heat-seal” adhesive with high tack, which is strong, flexible, reversible (with heat or solvent) and can be diluted as desired [10,12,26].

<sup>13</sup> BEVA® 371 contained two EVA copolymers (A-C Copolymer 400, Elvax 150), a ketone resin tackifier (Ketone N, later Laropal K80), a secondary tackifier a phthalate ester of a technical grade hydroabietyl alcohol (Cellolyn 21) and paraffin wax [26,27,33]. According to ([http://www.conservation-support-systems.com/system/assets/msds/New\\_Beva\\_Formula](http://www.conservation-support-systems.com/system/assets/msds/New_Beva_Formula)), BEVA® 371b uses an aldehyde resin to replace Laropal K80 (formerly Ketone N, a polycyclohexanone resin) used in the original formula.



Two aspects were considered: active flaking in significant areas as well as cupping paint. To address both problems at the same time it was decided to consolidate through facing tissues [12]. This allowed the adhesive to penetrate the paint composite without the risk of losing or dislodging paint. The adhesive was then further activated using heat which also plasticised and helped flatten the paint. It was prepared by dissolving BEVA® 371b in white spirits (60:40) and warming the solution in bain-marie.

The method was tested in a small area in terms of application, reactivation/flattening and removal with solvent. Two pure solvents were tested to remove the tissue: white spirits and Shellsol D40. The best result was obtained using Shellsol D40 which worked very well and quickly removed the surface excess without disrupting the BEVA® 371b (unlike white spirits that gelled/swelled the surface BEVA® 371b and had time to penetrate the cracks and disturb the adhesive). Testing revealed a practical problem concerning air bubbles that were created between the tissue and paint surface during the application of the warm adhesive with a brush. The solution was to moisten the tissue between wet blotting papers for 30 seconds (prepared as explained in chapter 5.1) and to quickly place it on top of the painting, then brushing it with BEVA® 371b. The cellulose fibres were relaxed with humidity therefore conforming perfectly to the surface.



**Figure 7** - Stages of the consolidation: application of the tissue in a damage area; use of the heat spatula to reactivate the adhesive and flatten cupping paint.

### **5.3.Facing**

To protect the paint while working on the back to remove the old lining and lining adhesive, it was necessary to face the painting. Facing, a temporary treatment, involves adhering a material which conforms closely to the surface to the face of the painting [10,12]. The choice of Japanese tissue paper and adhesive is dependent for the level of protection and consequent treatments but they should: form a good bond with the paint surface; be readily reversible, and be compatible with materials used in later stages of the treatment [10,12,33].

The use of an aqueous adhesive such as a 3% gel formed with distilled water and sodium carboxymethylcellulose (NaCMC) was considered and tested with success on a small square of the painting. As a gel it involved a lower level of penetration into the painting and could be easily removed with water. However due to the fragile condition of the paint resulting in overall cupping and flaking paint, a full consolidation would be required first. To avoid separating consolidation and facing into two separate steps, a practical decision was made to face with BEVA® 371b (60:40 in white spirits) which would also

serve to consolidate at the same time. Further testing confirmed that this procedure would work well and leave the paint surface unchanged.

Prior to facing, square tissues of Japanese tissue (see Suppliers) were created using lines of water and tearing to separate the tissue while wet, thus forming feathered edges. Facing tissue squares were placed on top of the painting to plot the correct placement and amount. Although a simple math equation had given the number of squares needed (with different sizes for edges and corners) adjustments were necessary to avoid having one square ending in the middle of a loss and therefore not providing the necessary continuous support. Generally 10x10cm tissues were used.



**Figure 8** - Facing tissue perfectly conformed to the paint surface.

The adhesive was brushed onto the tissue squares alternating in a chess-board pattern to have dry areas adjacent to wet so that moisture did not build up excessively in a localised area [12]. As above the tissue had been moistened to avoid air bubbles and gain maximum conformation to the surface (Fig. 8, VII.2).

Along the edges, squares of facing tissue extended from the painting onto lengths of wood mounted flush with the level of the painting. The facing tissue formed a bridge between the paint and the wood, adhering to both and thus securing the edges from any distortion introduced during the application of adhesive (particularly important for aqueous based facing adhesives) (Fig. VII.1, VII.2). Prior to facing the edges, silicone coated Melinex® was placed between the original and lining canvas to ensure that they did not get re-adhered by the facing adhesive.

For safety reasons, It is important to note that any time solvents were used protection was necessary requiring the use of gloves, mask and extractors above the painting (Fig. VII.14).

After drying, silicone coated Melinex® was placed under the painting and above the facing tissue, allowing the BEVA® 371b to be heated with the heat spatula (around 60°C), “plasticising” the paint and flattening more pronounced areas. Even though not all areas responded as quickly as desired, where necessary, heating was repeated and weights were left on top to allow the paint to cool while held in place.

#### **5.4. Removal of the stretcher and lining canvas**

Once dry, the facing between the painting’s edges and the wood was cut, releasing the newly faced painting and allowing access to the back. To separate the lining canvas from the stretcher it was only necessary to pull the fabric away from the oxidized tacks. In order to turn the painting face down, a sandwich system was created: first a thin sheet of foam covered with Melinex® was placed on top of the painting followed by an 8 ply matt board. The painting already rested on a support board consisting of fluted polyethylene. With both top and bottom boards held in place by hand, the painting was inverted leaving the Melinex® covered thin foam sheet now between the face of the painting and the 8 ply matt board, serving as a support while work commenced on the back.



Once the stretcher was removed, the back of the lining canvas required surface cleaning (with the brush end of the vacuum cleaner) to get rid of the significant dirt, dust, mould and insect casings present (Fig.VII.3, VII.4), (this process was also repeated for the stretcher).

To remove the lining canvas, already loose edges were further released from the original fabric, and with slight pressure, the painting was held down while the lining canvas was gently peeled back at a very low angle (Fig. 9). This procedure was very straight



**Figure 9** - Removal of the old lining canvas by pulling in a very low angle.

forward and the lining canvas came off as a whole piece. Following removal of the lining canvas the back of the original canvas had to be vacuum cleaned (brushing with a soft brush into the nozzle of the vacuum cleaner) again to eliminate mould, dust and dirt.

### **5.5. Strip lining and looming**

Since the painting was no longer attached to anything it was necessary to place it under tension. This was done by strip lining it with polyester fabric strips (see Suppliers) and BEVA® 371 film (see Suppliers) onto a temporary loom (wooden frame).

A strip lining is the reinforcement of the original edges [31] by adding new borders to strengthen or replace tacking margins [11]. This can be used as the only structural treatment required to place the painting under tension only if the “foldover edge and/or tacking margins are compromised or inadequate” [12]. BEVA® 371 film and polyester fabric are materials often used for this purpose and had proved to be effective [31]. In this case a relining was necessary since the original canvas has lost its strength and both painting and replacement strip need to be uniformly supported. However prior to the lining there were many steps involved which required having the painting under tension, hence the necessity of a temporary strip lining and looming.

Strips of BEVA® 371 film (2,5 cm wide) were adhered to the polyester fabric with a hot spatula (approx. 70°C). The fabric strips were then adhered to the back of the painting with a hot spatula (approx. 65°C) around the edges (covering the original canvas by 2cm). The old lining adhesive had already been scraped off to ensure good adhesion. Next the fabric was stretched onto the loom and pushpins were used to fix the fabric onto the wood, avoiding the application of force and vibration often associated with hammering or stapling with a staple gum. Other practical issues were solved by the use of pushpins as they are easy to remove and re-adhere both to adjust the tension or to re-orient the painting in the loom (either face down or face up, according to which side required a solid support during treatment), see Fig. VII.5 and VII.6.

### **5.6. Removal of the lining adhesive**

The removal of the lining adhesive (de-lining) proved to be a highly labour intensive procedure. As stated by Ackroyd [32] there are not many improvements in de-lining methods even though the reversibility

of linings is an important subject. Depending on the painting and the adhesive used, either wet and/or dry methods can be used, however the most reliable practice is to use mechanical action to remove the adhesive residue [12].

To begin, a dental instrument (a pick tool) and a scalpel (blades 11 and 15) were used to scrape the old adhesive and assess how difficult it was to remove. Two types of situations were encountered: very dry and powdery adhesive (where attacked by mould) and very hard “concreted” areas thought to be the result of the adhesive being saturated with water when the painting suffered water damage. While the first could be easily removed with the pick tool followed by vacuuming (with a brush on the vacuum nozzle), the second was extremely difficult and sometimes even impossible to remove with this method. This problem led to the exploration of different methods, especially aqueous methods that could soften the adhesive:

⇒ Moist blotting paper: a small piece of moist blotting paper was placed on top of a more concreted area of old adhesive, covered with Melinex® and a light weight to ensure contact, and left for 5 minutes. After this time, the soften adhesive was scraped and it was possible to see that in some areas the canvas was saturated indicating that the adhesive had penetrated into the canvas interstices (Fig. VII.8);

⇒ Sodium carboxymethylcellulose (NaCMC):

⇒ Tylose gel:

In both gels, a 3% solution in distilled water was brushed on top of a small square of Reemay or a more permeable tissue (facing tissue) and left for 30 seconds to 5 minutes, then the adhesive was scraped and depending on the result, the process was repeated or left to dry and scraped again. Once more, the darkness of the canvas suggested that the adhesive was being driven into the canvas and was saturating the fibres.

⇒ “Hot distilled water”: heated water (approximately 75°C) was applied with a cotton swab onto an area of concreted adhesive and scraped. Since this gave a good result, a larger area was tested by applying the water with a natural sponge and once again scraping. However this method proved to be unreliable since it was extremely temperature dependant, which means that it would only work in very small areas with the procedure done very quickly, and there was difficulty controlling the degree of wetting that occurred, with the fear that the canvas itself could be saturated with water.

None of these methods showed any improvements over the dry mechanical method, since they all required scraping and still the adhesive was not completely removed, and in some cases it was even driven further into the fabric. As well, these methods were more dangerous for the painting due to the moisture involved and the difficulty of controlling it. The use of Enzymes was another hypothesis also considered (see discussion Appendix VIII).

Another method for mechanical removal was investigated involving the use of a Dremel tool. This Multitool System<sup>14</sup> can be used for a variety of applications, including very precise work (such as engraving, carving and polishing). A Dremel was tested with different accessories available in the local hardware store. The best one was a 0.8mm engraving cutter which due to its shape could “shovel” the concrete adhesive very easily. However the tip revolved at too great a speed to be properly controllable. This problem was solved<sup>15</sup> with the use of a potentiometer (Fig. VII.7, VII.11, and video in DVD) based on an adapted dimmer switch. This device regulates the voltage to allow the tool to work much more slowly and therefore with greater control than at its standard setting. This method, applied to concreted areas (Fig. VII.9, and video in DVD), complemented the use of the dental tool and the scalpel which were used for more powdery areas. A magnifying glass with a ring light and a stereomicroscope were used to improve visibility of the surface during this sensitive work.



**Figure 10** - During the old adhesive removal (dark area is where the adhesive is still present)

Despite the time involved (approximately 139 hours) this step was essential to guarantee that the original canvas was prepared for the new lining (Fig. VII.10, VII.12). Otherwise residues of old glue could interfere with flattening treatments and cause distortions and lack of adhesion to the new canvas during lining.

### **5.7. Consolidation of the back**

The removal of the adhesive revealed small scattered damaged areas including abrasions and losses through to the ground layer. Losses required filling to ensure the paint would not develop distortions during further treatment, visible at the front. Consolidation was done with formed sheet of fill material comprised of 10g of BEVA® 371b and 7.5g of kaolin (Modified BEVA® 371). This material allows great control: small pieces were cut to size with a scalpel and surgeon's scissors, then placed in the losses (manipulating them with tweezers under the stereomicroscope). With a piece of silicone coated Melinex® on top of the fills they were melted in place with heat spatula at approx. 70°C (Fig. VII.13).

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<sup>14</sup> <http://www.dremeleurope.com/> and <http://www.dremeleurope.com/gb/en/engraving-cutter-0-8-mm-104-ocs-p/?jsessionid=108C344A7D753325C5A1A9F958CECE6A.sl076-vm>

<sup>15</sup> By a store assistant from the local hardware store (Leroy Merlin), that kindly offered to build a device.

### **5.8. Removal of the facing**

BEVA® 371b is soluble in hydrocarbon solvents including low-aromatic petroleum solvents<sup>16</sup> [33].

While previous tests indicated that Shellsol D40 (<0.4% aromatic content) was quick and efficient to remove the facing tissue and BEVA® 371b residue, after the facing had been in place some months, this solvent was no longer as efficient, taking longer to react and leaving significant adhesive behind on the surface. Further testing led to the use of Shellsol A (>97% aromatic content) which proved effective. After wetting with Shellsol A the tissue lifted very easily without mechanical pulling and although some excess BEVA® 371b was still present on the surface it could be removed with a second passage with the cotton swab (Fig. VII.14). This step also removed surface dirt along with the adhesive. During removal excess solvent on the paint was rapidly absorbed with dry cotton.

### **5.9. Varnish cleaning testing and partial removal**

There are different possible aesthetic choices and approaches to clean a painting, and ultimately cleaning is an act based on critical interpretations [12] that should be considered individually in each particular case. Generally, whether to clean and how far to clean can provoke controversy [12, 34].

Due to the severely deteriorated and discoloured varnish over the portrait, colour relationships were subdued and details (for example in the fabric) that could give depth and “quality” to the painting were “flat”. The flesh tones were very distorted as well. After careful consideration it was decided to carry out varnish removal.

Solvent tests to establish safe varnish removal were performed. While cleaning was not a priority for this thesis, tests were performed to establish the solvent system required to remove the varnish as this was essential to determine whether the solvent(s) could compromise the sequence of steps in the overall treatment. Furthermore the removal of severely blached varnish was necessary at this stage to regain the image near the missing strip in order to evaluate the surface texture and for possible pre-colouring of the infill.

As explained by Alan Phenix and Richard Wolbers in *The Conservation of Easel Paintings*, the use of organic solvents to remove an aged varnish is based on the selection of a solvent with a strong dissolving effect on the varnish coating and negligible effect on the original paint, providing a controllable activity with minimal risk to the paint [12]: “Aged (spirit) varnishes tend to show reduced overall solubility and require progressively more polar solvents as a consequence of ageing” [12] The widely used natural resins, dammar and mastic, have been extensively studied in terms of their solubility behaviour [12, 35,36]. The solvent power and selectivity can be adjusted by mixing solvents with different solubility behaviours. A common solvent mixture used is a polar solvent with a non-polar solvent [12] (for example: Isopropanol and Iso-octane).

Pure Iso-octane had no effect on the varnish, while pure Isopropanol acted very quickly and effectively but with poor control (Fig. VII.15). Two mixtures were tested: 6:4 and 4:6 (Iso-octane:Isopropanol) and complemented each other since in more damaged areas the 'less active' solution allowed greater control, and the 'more active' solution could remove the varnish layer faster and more easily. The 4:6 mixture had a good rate of action and could be controlled in most areas. It was also tested on more sensitive colours (such as the red in the neckline) and no colour was picked up on the swab. However in the blached area

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<sup>16</sup> [http://www.conservation-support-systems.com/system/assets/msds/New\\_Beva\\_Formula](http://www.conservation-support-systems.com/system/assets/msds/New_Beva_Formula).

along the bottom a dark green colour was affected, requiring a change to the 6:4 mixture. While this mixture was more controllable it only removed part of the degraded varnish leaving some blanched partially dissolved varnish behind, which still cause light scattering and disturbed the visual appearance. In the lighter green colour also along the bottom area, the 6:4 mixture appeared to be affecting only the varnish, but in the darker green areas (or more damaged/blanched paint) a brown tinge mixed with a green tone was visible on the cotton swab. This may be the result of a damage to the paint due to the water exposure in this area (evidenced in the blanched varnish). The binder could also have been compromised due to prolonged water contact.

In day light, and with careful observation of the dress by saturating the colours with an application of white spirits over the surface, transparent brown brushstrokes were evident (likely a glaze). There was concern that the brown tinge noted above could be evidence that this layer was being affected by the solvent mixture. Also it was possible to see a similar transparent brown glaze painted on the corset, creating a floral pattern (Fig. VII.16).

A glaze is a layer of transparent or semi-transparent paint applied to modify an underlying colour; it is usually done with dark, translucent paint over lighter, opaque paint [10,11].<sup>17</sup> As stated by Carlyle [13] the binder for a glaze could include resin as well as oil, with the proportion varying. Therefore glazes can have a different solubility than other areas of oil paint. Solvent removal of varnish over a glaze can be a very complex problem such that only a partial cleaning is possible. Solvent testing also revealed that areas of overpaint were soluble in the 6:4 solution, with concern that the overpaint over the background may be very extensive, and full removal may not be desirable.

Varnish removal trials over a larger area were carried out in the flesh tones of the arms and hands in order to establish with confidence the colour of the varnish on the white cotton swabs. To avoid overcleaning in a small area and the consequent struggle to match adjacent areas in terms of the amount of varnish removed, the cleaning was made in stages to maintain an even surface (in some areas tiny spots or small areas of varnish residue were evident).

A test showed that a sample of textured infill material (BGP, see below) from the replacement strip could be damaged by the solvent mixture used to remove blanched varnish along the bottom edge of the painting. Therefore this blanched varnish was removed prior to the lining and positioning of the replacement strip. Since the paint in this area was particularly fragile another solvent mixture (2:8 isooctane:isopropanol) was used to achieve a faster varnish dissolution with almost no mechanical action required. Despite good results there were still concerns with the green paint, so only the most severely blanched varnish closest to the edges was removed (Fig. VII.17).

#### **5.10. Creating a textured surface for the replacement strip**

The description of goals, materials choice and methodology has already been discussed (see Chapter 4 and [51]). Therefore this section focuses on the practical steps taken to achieve the final strip. Details of the tests and trials are in Appendix IX.

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<sup>17</sup> Essentially a glaze uses transparent pigment, i.e. one with a low refractive index (e.g. lake, ultramarine, copper resinate, Prussian blue) in most cases it has a higher vehicle/pigment ratio and often a resinous content [10].

### **5.10.1. Casting the texture mould**

The production of a replacement strip matching the painting's texture required the construction of a textured silicone mould of the paint's surface. As will become apparent, the mould had to be of uniform thickness and be wider and longer than the final replacement strip.

To protect the paint surface from the silicone mould material, a selection of thin plastic films were explored to find an appropriate barrier film.<sup>18</sup> One product, a low-density polyethylene (LDPE) was sufficiently thin (0.0005 cm) (see Suppliers) and flexible enough to conform well to the surface when the painting was under full vacuum on a cold table (see Equipment).

An economical two-part silicone mould material (Duplosil®, see Suppliers) had a reasonable working time of 5 minutes and a cure time of 20-30 minutes. In tests it had no effect on the plastic barrier film and it was possible to achieve a good cast of the topography of the painting without significant loss of detail. Evaluations were carried out initially on small test surfaces prior to being used on the actual painting. Challenges were encountered when scaling up from small trials to the full sized mould (12 cm x 70 cm x 0.2 cm). This has been detailed in the publication based on the crafting of the replacement strip [51].

Steps to create the silicone texture mould:

⇒ The painting (faced and loomed with the lining adhesive fully removed), was placed under low vacuum, and the plastic barrier film was gently adjusted by hand to remove creases or folds as the air was extracted. Then the vacuum was turned on to maximum, and left for a minimum of 10 minutes (the longer the vacuum was left on, the better the plastic would conform to the painting) (Fig. VII.18).

⇒ A barrier for the silicone mould material was created around the area chosen for casting by using two strips of white plastic (1.55 cm wide x 0.2 cm deep by 100 cm long) (see Suppliers) glued to the barrier film with a line of Duplosil® (applied with a syringe (Fig. VII.19). The textured mould was made significantly wider and longer (12 cm x 70 cm x 0.2 cm) than the final replacement strip would be, such that the excess could be cut off, ensuring clean edges for casting the strip of infill material (see below).

⇒ The silicone was poured and levelled with an 8 ply matt-board applicator (Fig. VII.20). After 40min the vacuum was turned off and the plastic and silicone removed.

The same procedure was repeated three times, resulting in two satisfactory moulds (evenly level, with good thickness and texture). The last one made was the best since practice led directly to improved handling techniques and results. The moulds were stored flat on an 8 ply matt board, underneath a dust cover which was suspended above the mould (the silicone easily attracts dust and dirt, and the plastic film sticks to the mould when in direct contact).

### **5.10.2. Production of the replacement strip**

To apply a uniform film of BGP with the required thickness, a platform for the textured mould was created, with guides on either side at a fixed distance and the correct height above the mould (Fig. VII.21, VII.22). White plastic strips<sup>19</sup> were placed on top of strips of thin (0.027 cm) plastic sheets (sold as table mats) cut to size. All layers were held in place with double sided tape. A rigid applicator was pulled along

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<sup>18</sup> Their use was introduced by Jos Van Och (SRAL) for his Mist Lining technique.

<sup>19</sup> Smooth white plastic guides (1.55 cm wide x 0.2 cm deep by 100 cm long) (see Suppliers).

the smooth uninterrupted surfaces of the white plastic guides in order to spread the BGP evenly. Several options were explored and the applicator chosen was a piece of lightweight corrugated Lexan (23.5 cm x 12.5 cm x 0.4 cm) with a section of the white plastic strip (used as thickness guides) forming a straight edge (it was held on with double sided adhesive tape) (Fig. VII.22).

The Duplosil® exhibited severe distortions immediately upon contact with large amounts of BGP (not evident in initial trials with small amounts of BGP). Therefore a piece of thick Melinex® (12 cm x 70 cm x 0.01 cm) was placed over the spot where the BGP would be poured (Fig. VII.21). In the first attempt to spread the BGP, the Duplosil®, was unable to expand across its width due to the thickness guides and distorted dramatically along the edges. The solution was to design 'break away' thickness guides that could be removed immediately after the BGP film was formed, thus allowing the silicone unrestricted expansion (Fig. VII.23). Further fast action involved the use of a hairdryer blowing cool air over the length of the strip until the distortions in the Duplosil® were reduced and the BGP film was surface dry (approximately 30 minutes).<sup>20</sup> An 8ply matt board cut to size was placed over the whole BGP strip once it was surface dry, then boards and weights were placed on top to hold the strip flat while it fully dried (between 14-20 days - once solvent was no longer detected by smell the BGP and Duplosil® were considered dimensionally stable).

Oddly, the swelling and distortions in the silicone mould (mainly in the first strip) did not affect the accuracy of the transfer of texture to the BGP.

The intention was to apply a piece of white polyester fabric on the back of the textured infill strip. This layer would work as a support, to help handling and in theory to provide the same mechanical adhesion as the painting during the lining (fabric with fabric). So, with the first layer of BGP dried and still in place on top of the textured silicone, a second layer was applied, also acting as the adhesive for the application of the polyester fabric.

At this stage, once again scaling up became an important issue. The small sample test of a textured infill strip (8 cm x 3 cm) with the polyester fabric was a success, but after a full size strip (70 cm x 12 cm), was left out in the studio to dry, it was noticed that it developed a convex distortion (fabric side up). The distortion immediately disappeared when the fabric was peeled off. On its own the BGP strip was perfectly stable dimensionally, and furthermore it was not prone to tearing despite its thinness. Therefore after testing the BGP strip with Mist lining trials and determining that it adhered well on its own, the polyester fabric was eliminated from the strip construction. An advantage of eliminating the fabric was that the back of the final strip could be sanded to adjust its thickness to the painting (using a sanding block and thickness guides).

Alternatives to BGP for a second layer (needed to achieve the thickness required) were considered since distortion of the mould due to the solvents introduced in the second application was feared. The option of removing the Duplosil® mould prior to application was rejected as the mould acted to hold the first layer in place during application of the second.

Adhering two dried layers of BGP together with various adhesives (acrylic emulsion, BEVA® 371 film plus heat) was explored but did not have the same success experienced by simply applying a second

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<sup>20</sup> Based on diluting the BGP with Shellsol D40 to a spreadable consistency, from the time it was poured onto the strip of textured silicone and spread over the surface, the working time was in the range of 2 minutes. Drying time through evaporation took much longer (as noted above).



BGP layer directly on top of the first. Trials in small samples indicated that the second layer would not cause distortion of the Duplosil®, and for once, scaling up did not introduce a new problem.

A successful two-layer BGP textured strip was produced by applying the second layer using thickness guides and the applicator. This second layer of BGP evened out the back of the first layer and when dry the strip was sanded down to the final thickness where required (Fig. VII.24). A Melinex® template was used to guide the cutting of the BGP strip, with a scalpel and surgeons' scissors. The final edge of the strip was as close a conformation to the edge of the remaining paint and canvas as possible (Fig. VII.31).

A light ivory toned water colour was brushed onto the strip to highlight areas requiring further attention, such as small imperfections in the mould that would need individual work with local filling and shaping using BGP (Fig. VII.25).

### **5.11. Relining**

Relining is a term used when a painting has been lined before and receives another lining treatment (involving the removal of old lining canvas and adhesive) [10]. The term lining refers to adhering a new fabric to the reverse side of a painting canvas, in order to stabilize structural weakness in the original canvas [10].

The chosen method for lining the painting was the *Mist Lining* with acrylic dispersions. This technique, developed by Head of Paintings Conservation at the SRAL institute, Jos van Och [37] was used successfully for the lining of the portrait of *João Luiz Lourenço* (FCT-DCR Master's thesis by Joana Devesa [3]). Its success and the fact that both portraits will be displayed and stored in the same conditions encouraged the use of this technique [37]. Most of the choices (fabric, adhesive mixture) were also applied in this case and followed the same reasoning as discussed in Devesa's thesis [3], however the information and documents pertaining to this method were closely reviewed and its practical application was tested prior to this lining.<sup>21</sup>

*Mist Lining*, a technique developed from "cold lining" [38], received its name from the method of spraying the adhesive onto the lining fabric in a fine mist. It is a nap bond technique<sup>22</sup> that respects the "authentic character and structure of the painting" [37]. The adhesive is allowed to fully dry (24 hours) and is then reactivated with solvents during the lining procedure in a low pressure system. The result is a light attachment between the lining canvas and the aged support [37]. Some of the advantages are that it,

- ⇒ Does not constrain the flexibility of the painting [37];
- ⇒ Assures future reversibility due to the open structure of the glue layer [37];
- ⇒ Allows individual features to be selected according to the requirements of each treatment (canvas, adhesive, reactivation solvent, etc.) [37];
- ⇒ Minimal use of adhesive and the elimination of moisture (dry adhesive layer) [38];
- ⇒ Use of solvent vapours to reactivate the solvent [38];
- ⇒ Only low pressure required to create a good bond. [38];

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<sup>21</sup> DVD: *ICOM- CC Paintings Group Workshop Current Practice and Developments in the Structural Conservation of Paintings on Canvas Supports*, Helsinki Metropolia University of Applied Sciences, Degree Programme in Conservation, Vantaa, Finland 16-18 September 2010.

Notes taken by Dr. Leslie Carlyle, Sara Babo and Diana Conde during a Mist Lining workshop in S.R.A.L. Maastricht, Netherlands (2011). And Och Articles [37,38]

<sup>22</sup> The adhesive is applied in the lining canvas, not to the original canvas, which provides a uniform hold at the nap surface [10].



## Lining Preparation

A polyester fabric dyed to imitate canvas<sup>23</sup> (see Suppliers) was washed in a washing machine using tap water and ironed, then stretched and stapled to a wooden loom. The contours of the the painting, including the addition of the replacement strip was drawn with pencil onto the centre of the lining fabric leaving an excess of fabric around all edges (97cm x72cm) to allow attachment of the lined painting onto its new stretcher (Fig. VII.26). To raise the nap of the fibres (in order to facilitate adhesive application in a web-like structure), the lining fabric inside the area designated for the painting and replacement strip was sanded (wood block wrapped with n°40 sand paper) in both vertical and horizontal directions. This area was then vacuumed to remove sand paper residues and leave the fibres sticking upwards [37]. The rest of the canvas and the loom were protected with plastic sheets held in place with masking tape (Fig. VII.27, VII.28). Because of the mist of adhesive created during spraying it was necessary to protect all surfaces in the room where the adhesive was applied (Fig. VII.27).

The solvent reactivation of the adhesive is achieved by introducing solvent into a carefully measured piece of cotton “cheesecloth” (thread count: 35x42cm<sup>2</sup>) with the chosen solvent (cheesecloth dimensions: 94cm x 72cm, which includes the dimensions of the painting and replacement strip dimension plus 10%<sup>24</sup>). The total surface area of the painting and replacement strip (0.5676m<sup>2</sup>) was used to calculate the amount of adhesive to prepare: 1m<sup>2</sup> requires 200ml of adhesive, therefore 114ml of adhesive was required. The adhesive mixture can be adjusted according to the strength of the bond required. Since the Devesa treatment gave an excellent bond, the same proportions were used: 60% Plextol K360 and 40% Plextol D540<sup>25</sup> (see Suppliers).

A solution of 200 mls adhesive was prepared. Since the initial pH of Plextol K360 is 3, 120 mls of this was raised to a pH of 7 with 25% ammonia, to make it neutral, then 80ml of Plextol D540 was added and the mixture stirred with an electrical mixer while approximately 1ml of thickener (Rohagit SD 15) (see Suppliers) was added until the desired consistency.

The adhesive was filtered and applied to the lining canvas in a thin coating using a spray gun<sup>26</sup> held approximately 15 cm from the canvas surface at an angle (around 30°). The adhesive was applied continuously from top to bottom and then across from one side to the other to make sure that the fibres were completely covered and an open network of adhesive was created (Fig. VII.27, VII.28). The adhesive was left to dry for more than 24hours allowing moisture and solvent to evaporate.

Prior to lining, the painting was placed face down and taken off the loom. The strip lining was reversed using a hot spatula (approx. 70°C) to soften the BEVA® 371 film, such that the polyester fabric was gently peeled off.

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<sup>23</sup> Polyester fabrics have low water absorption, no swelling (dry quickly), are stable up to 130°C and show good light resistance [10].

<sup>24</sup> Because impregnation with solvent can cause the tissue to shrink.

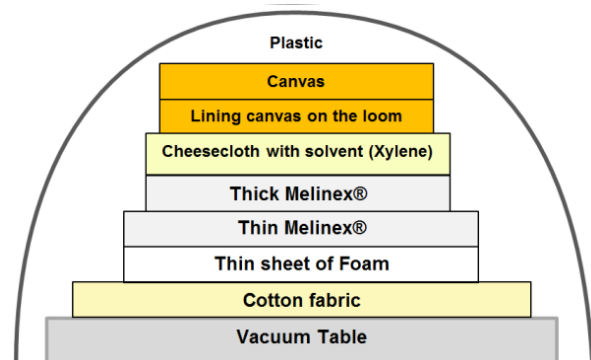
<sup>25</sup> Both Plextol are acrylic dispersions, Plextol K360 is an aqueous dispersion of a thermoplastic acrylic polymer based on 2-Ethyl hexylacrylate (conc. approx. 60%); Plextol D540 is an aqueous dispersion of a thermoplastic acrylic polymer based on Methyl methacrylate and ethylacrylate (conc. approx. 50%); The thickener Rohagit SD15 is an aqueous dispersion of acrylic polymer based on: methacrylic acid and ethylacrylate (conc. approx. 30%). Information available in [www.kremer-pigmente.com](http://www.kremer-pigmente.com).

<sup>26</sup> Using a 1.3 nozzle oriented in the horizontal position with a pressure of 3bar.

## Lining

The first step was to position the painting and replacement strip on top of the dried adhesive while the lining fabric (stretched in a loom) was lying on the vacuum table on top of cushioning material.

As the diagram shows (Fig. 11), directly on top of the vacuum table was a cotton fabric with a close weave to allow a good air circulation, then a thin sheet of foam (0.3cm thick) covered with a sheet of very thin Melinex® (approx. 12µm). Next a sheet of thick Melinex® (0.01cm) was placed on top (to ease removal of the cheesecloth impregnated with solvent). During the lining processes solvent soaked cheesecloth is placed between this Melinex® layer and the underside of the lining fabric to reactivate the lining adhesive (see below). On top of the loomed lining fabric the painting was



**Figure 11** - Diagram illustrating the various layers of materials used during the lining (based on Devesa's diagram [3])

placed over the area coated with the sprayed adhesive. Finally a thin plastic sheet that creates the vacuum and prevents the evaporation of solvents was placed over the top of the painting and loom.

The vacuum system was tested with all the elements in place to make sure a uniform pressure was achieved. Prior to this the cheesecloth had been prepared with solvent: first it was folded such that it formed a roll that could be quickly unfolded (as shown in van Och DVD<sup>21</sup>) then, wrapped tightly with several layers of plastic kitchen wrap ("cling film"). The solvent chosen was 100% xylene since it provided a strong bond without affecting the BEVA® gesso strip or the paint. To each 1m<sup>2</sup> of cheesecloth van Och recommends<sup>21</sup> 30 – 60ml of xylene to evenly moisten the fabric. In this case 34,2ml of xylene was injected into the wrapped cheesecloth. It was then placed under pressure between clamped wooden boards and the xylene left to diffuse for 2 hours.

Since the adhesive reactivation is achieved with solvent vapours alone, it was crucial that all steps take place as quickly as possible to minimize evaporation. It took four people to assist in the following steps: 1. the painting sitting on the lining fabric in its loom was raised above the Melinex® sheet. 2. The cheesecloth was unrolled and positioned on top of the sheet (the sheet had previously been marked so that the location of the cheesecloth was clear), 3. The painting and loom were repositioned over the cheesecloth and plastic sheeting was placed over the top to ensure no solvent vapour escaped. 4. The vacuum was then turned on for 20minutes to allow reactivation of the adhesive. As the vacuum was activated, the plastic was carefully spread to conform to the paint surface and weights were placed in the corners of the loom to keep the plastic in place during this step.

After reactivation (based on the time elapsed), the vacuum was stopped and the cheesecloth was removed. The plastic sheet was replaced over the painting and loom and the vacuum activated for a total of 2 hours (this held the painting and lining in close contact and secured the adhesive bond (Fig. VII.29). The lining worked very well and both painting and replacement strip exhibited good adhesion to the lining canvas (Fig. VII.30). The texture of the replacement strip was not affected by the solvent or pressure applied during the *Mist Lining* (Fig. VII.31).

### **5.12. Further Treatment**

This thesis concentrated on the structural treatment of the portrait, including the crafting of the replacement strip for the missing paint and canvas using archival quality materials. Future treatment is needed to continue the removal of discoloured varnish, to infill extensive and local losses in the paint, to stretch the lined painting onto its new stretcher, and finally, to reintegrate the textured strip by matching the painting in colour and texture. The latter is a formidable aesthetic challenge (see Conclusions).

The photo-chemical aging and resulting colour changes reported for BEVA® 371 and 371b may put the long term visual stability of the reintegration at risk, since, should the underlaying fill material shift in colour, it could mean that the reintegration no longer matches the original paint. This would shorten the useful life of the replacement strip. With this in mind, measures will be explored to minimise this risk, for example, the choice of inpainting materials and application, and the framing system (employing glass or acrylic glazing which includes UV protection – an ideal option is the Optium Museum Acrylic – 99% UV Protection from True Vue<sup>27</sup>).

The painting will then receive a final coat of a durable and visually appropriate varnish. Because of the uncontrolled environmental conditions for its display and storage, at the museum's request, a framing system providing protection against extreme daily fluctuations in RH will be designed and built to house this portrait and its companion.

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<sup>27</sup> Properties available in: <http://www.tru-vue.com/products/optium-museum-acrylic/technical-info/>



## **6. CONCLUSIONS**

New information about the history and dating for the two paintings was revealed as a result of this thesis project. The museum's records can now show that the period of execution for both is between 1840-1860, with greater precision possible for the female due to the visual analysis of her costume (1845-1855). Based on the combined results of instrumental analysis (materials present, and stratigraphy) as well as a stylistic analysis, a strong possibility could be established that both portraits were executed by the same artist. X-radiography proved to be an important tool in the comparison leading to a greater understanding the paintings condition and history, and revealing changes in their dimensions likely associated with the previous treatment.

Establishing the fact that the portrait of *Isabel Affonso* was a companion piece to the male portrait (now known to be her husband), was important to the treatment of the painting. It became clear that restoration to the original dimensions was essential to restore the context of the painting.

The sequence of steps in the full treatment required anticipating those steps to come. For example consolidation of the flaking paint at the outset necessitated a solution that would not compromise the removal of the lining fabric in a later step. With the exception of crafting the replacement strip, the treatment was straightforward, but uncovered a highly labour intensive step (removal of the old lining adhesive from the back of the original canvas).

The main challenge in the treatment was to create a replacement strip that would echo the texture and flexibility of the original paint surface. While rewarding in the end, due to the good results achieved, the development of the strip and the improvement of the techniques employed as well as the exploration of different materials was complex and demanding [50].

A great deal of knowledge was developed during the exploration of the materials for the replacement strip (Duplosil® silicone moulding material, BEVA® Gesso-P infill). This information about their properties and how to manipulate them, was crucial to the process of adjusting them to the requirements of the treatment.

This thesis demonstrates that empirical testing (with a series of trials) is crucial for a conservator. Also the use of analysis or qualitative testing (stress gauges) allowed a broader understanding of the material (in this case, BEVA® Gesso-P). Even though problems arose from scaling up to the full dimensions of the strip, the thinking involved led to flexible solutions to an uncommon problem.

### **Future research**

During the treatment, traditional methods to remove the old lining adhesive proved to be very time consuming. While a more efficient method was found (use of the Dremel tool with an adapted dimmer switch), it still left the question of whether a better method could be devised. Future research to develop safer and easier procedures is needed.

The question of the number of ground layers present in the male portrait remains for further investigation, since it was not clear whether the final layer of "ground" was in fact a paint layer. It will be useful to carry out further comparisons with the ground/paint layers present in the female portrait.

Also a study focused on BEVA® Gesso-P degradation and aging is strongly suggested, since there is no information regarding this compounded material.

The lack of environmental controls for the painting while on display or in storage was a consideration throughout the treatment design and implementation. Tests indicate that BEVA® Gesso-P is particularly unresponsive to changes in RH, making it an ideal choice for the replacement strip and for infilling remaining paint losses. However, as noted above, further protection will be provided by a specially designed framing system.

Finally, there remains an important issue regarding the choice of an option for the aesthetic compensation of the replacement strip. Reintegration choices are controversial, and require careful consideration not only by the conservators but also by the owner of the painting, since several possibilities exist and carry different ethical questions and values that have to be balanced.

Despite the open-ended discussion which remains, a conscious choice was made to create a textured replacement strip. Texturing is the only way to obtain an optimal visual integration, otherwise a flat surface would always be the main focus for the eye, bringing more attention to the strip than to the art work itself.

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## APPENDICES

A digital Appendix (DVD) is supplied in order to give more information and better resolution photographs of both portraits and the treatment of *Isabel Maria Lourenço Affonso*.

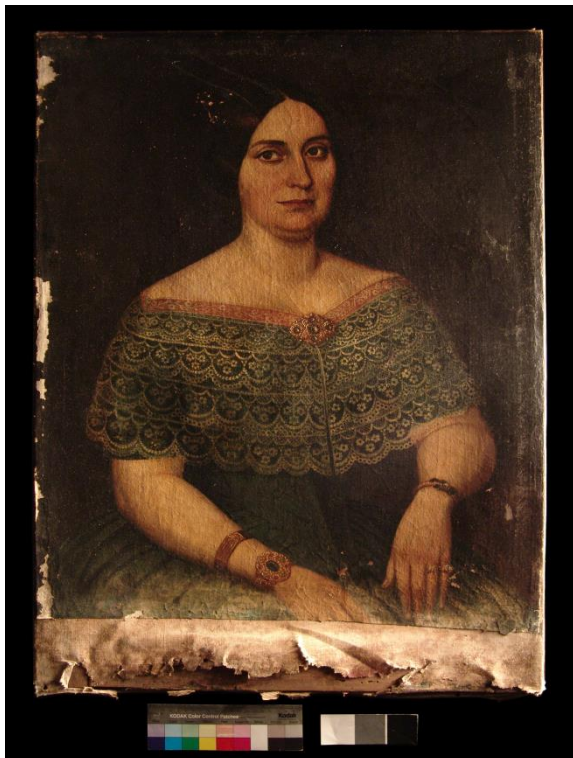
### APPENDIX I – OVERALL BEFORE TREATMENT PHOTOGRAPHS OF *ISABEL MARIA LOURENÇO AFFONSO*



**Figure I.1** - Normal light, front



**Figure I.2** - Normal light, back



**Figure I.3** - Raking light from the right side



**Figure I.4** - Raking light from the left side





**Figure I.5** - Ultraviolet (UV) Light.



**Figure I.6** - Infrared (IR) Light.



**Figure I.7** - Isabel Affonso X-radiograph.



**Figure I.8** – Domingos Affonso X-radiograph.

APPENDIX II – BEFORE TREATMENT DETAIL PHOTOGRAPHS OF *ISABEL MARIA LOURENÇO AFFONSO*



The labels have the name of the family that donated the paintings and the fact that they are equal (apart from the number given to each painting) allowed to complete the missing parts unravelling the full text present:

WOODBIDGE & Co. Ltd.  
88, Fenchurch Street, London, E.C.3. England.  
No. 00058  
Name Newberry  
[Nu]mber of pieces belonging [to this article or set]  
[Specialists for] Removals [to every dominion,]  
Colony and [Foreign land in the] World.

**Figure II.1** - Labels of a British transport company, present in the three paintings from Ecomuseu Municipal of Seixal. From *Isabel Affonso* (top), *Domingos Affonso* (bottom left) and *João Luís Lourenço* (bottom right).



**Figure II.2** - Water damage visible in the back of the lining canvas (dark tide line and mould growth) and in the stretcher.





**Figure II.3** - Detail of the missing strip and the lining fabric poor condition (torn, detached from the stretcher and with mould)



**Figure II.4** - Detail of the missing strip edge, with torn original fabric and missing paint.



**Figure II.5** - Detail of the missing strip edge, with paint projecting.



**Figure II.6** - Detail of Blanching.

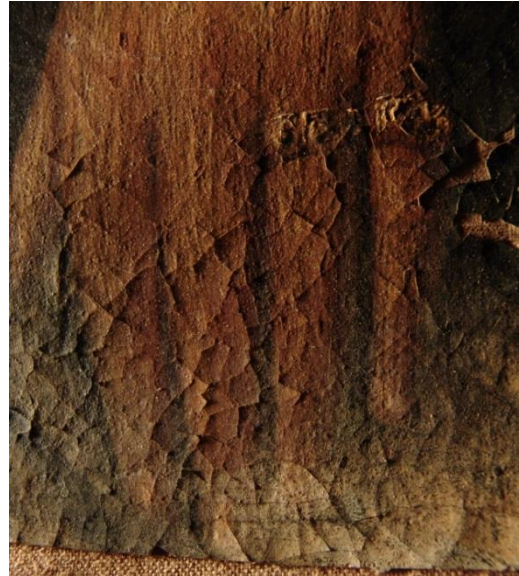


**Figure II.7** - Ground and paint loss.





**Figure II.8** - Raking light photograph, detail of a paint loss and canvas distortion.



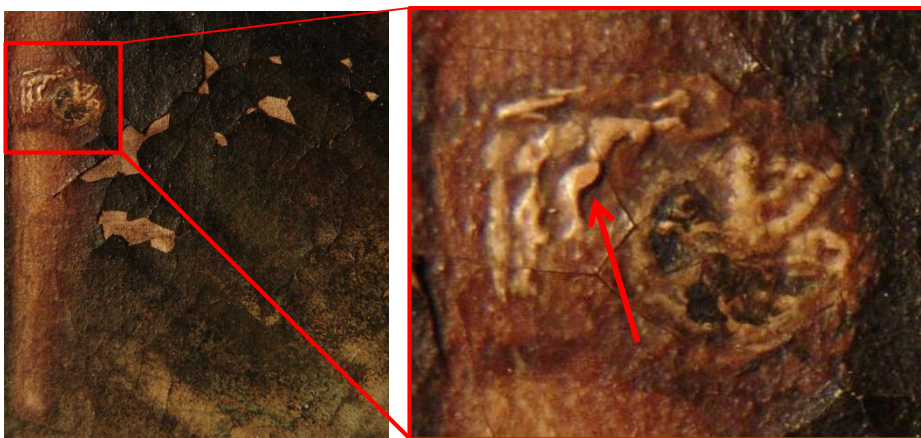
**Figure II.9** - Raking light photograph, detail of mechanical cracks and tenting paint.



**Figure II.10** - Oxidized taking margins, loss of tension, fabric no longer held under tension to the stretcher.

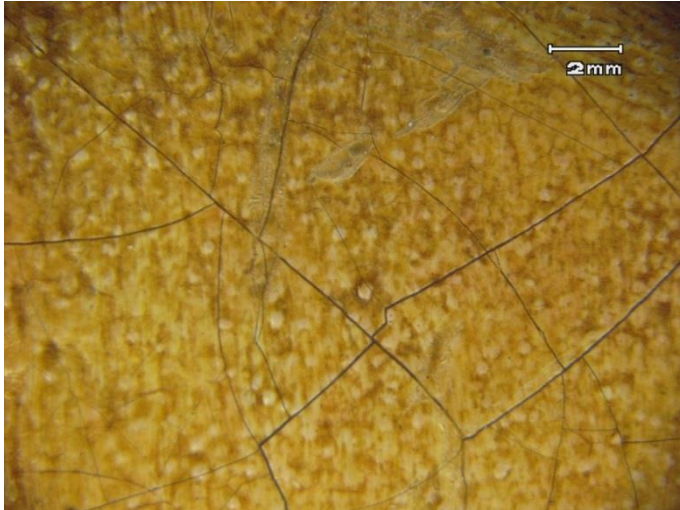


**Figure II.11** - The loss of tension in the lower area, cause the painting to depress into the stretcher bars.

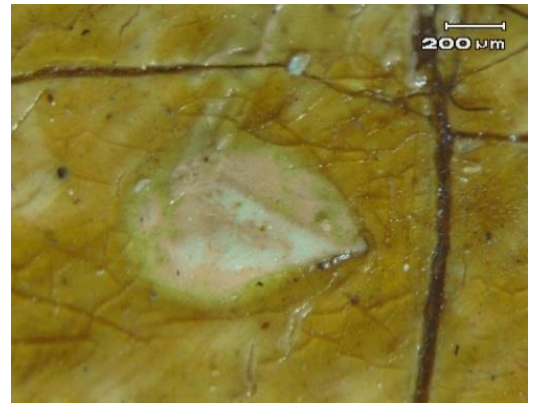


**Figure II.12** - Flattening of impasto. Detail highlighted with red arrow.

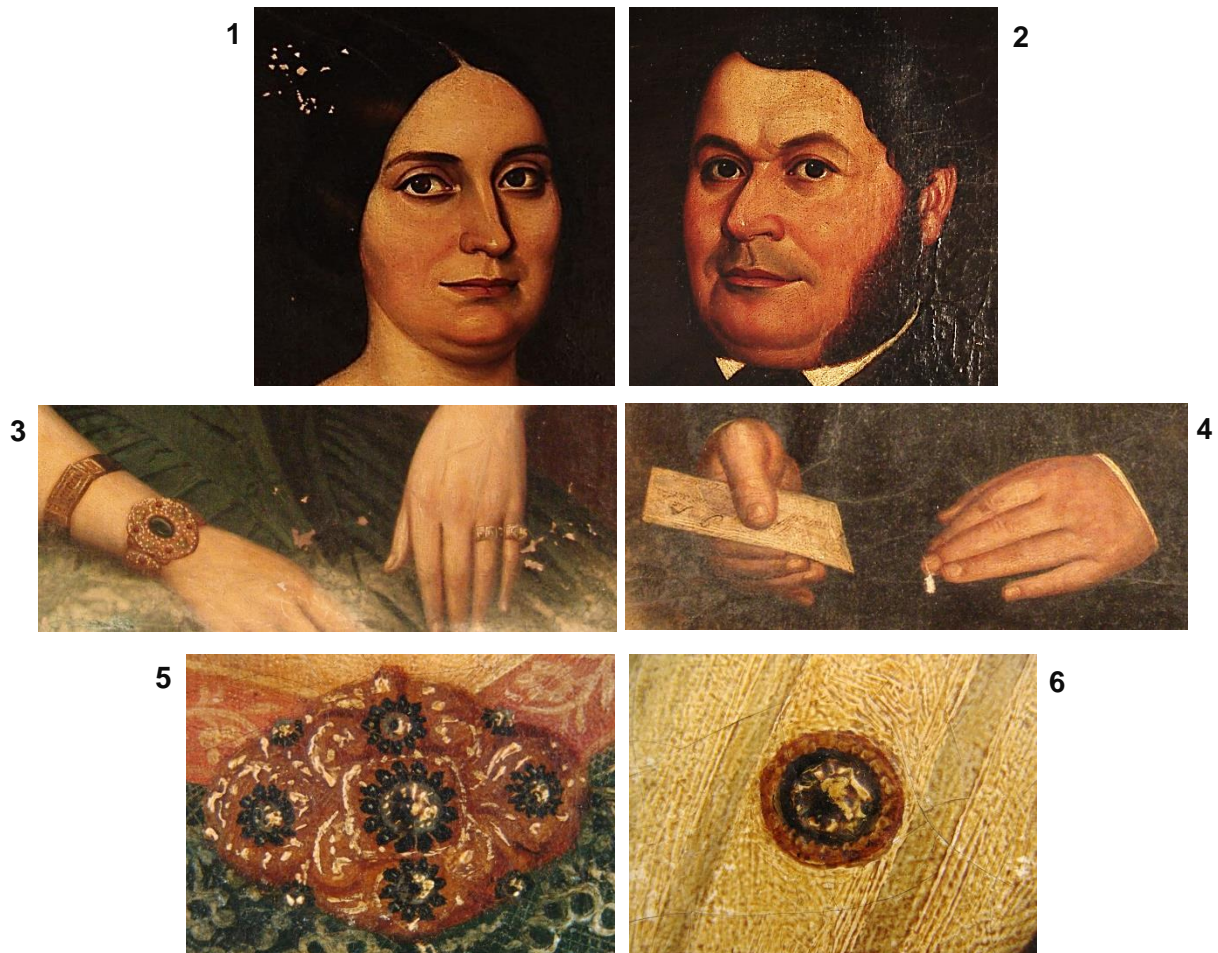




**Figure II.13** - Protrusions (small white dots), influencing the painting texture.



**Figure II.14** - Detail of one of the protrusions (shape and surface appearance).

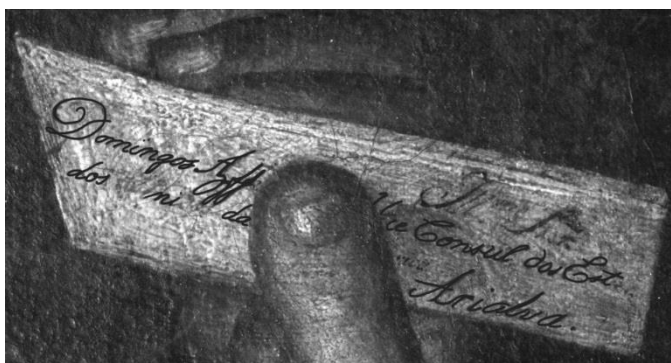
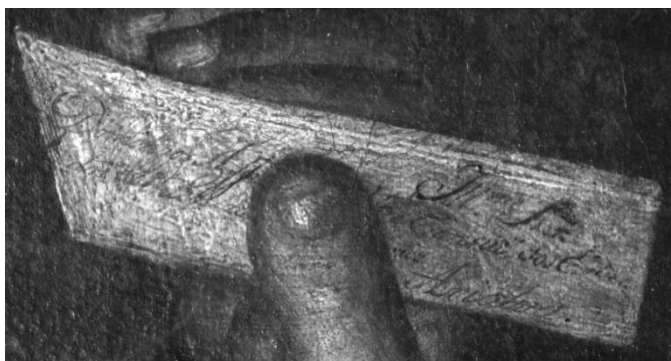


**Figure II.15** - Details from both paintings to allow visual comparison, female details on the left and male details on the right. 1 and 2: Face; 3 and 4: Hands; 5 and 6: Accessories.

### APPENDIX III – DOMINGOS AFFONSO

In terms of costume dating, *Domingos Affonso* is wearing a black civilian three piece costume (Fig. 35) that does not reveal specific characteristics, such as the cut of the pants or style of the coat; furthermore the yellowed varnish may be hiding information. The collar with turn-down points and cravat appears in Portuguese and American illustrations from the 1840 to 1850s. [8,9] The hair style and sideburns were popular between 1850 to 1860 although American references [9] mentioned the use of long sideburns as early as the 1840s. To cross-reference, the use of an American book [9] was thought to be relevant, considering that *Domingos Affonso* was the Vice Consul of the USA.

Regarding the painting condition, the lack of adhesion is of significant concern in local parts of the painting. The painting is lined and there is lack of adhesion of fabric, problem that is significantly more visible and problematic in the bottom margin of the painting where it was clearly exposed to water and both fabrics (original and lining) strength is weakened and slack or detached. However there are a few other areas where this problem is visible. Concerning the paint there are significant areas of tenting associated with cupping and active flaking (that occur at the interface of paint and ground and at the interface of paint/ground composite and the canvas), which leads to paint losses also visible in different areas of the painting. The largest missing area of paint and original fabric is at the bottom left edge and is approximately 2,8cm by 8,9cm. Overall there is yellowed varnish (natural tree resin) that obscures the image and a significant quantity of dust, dirt and what appears to be mould growth on the painting surface that needs to be removed.



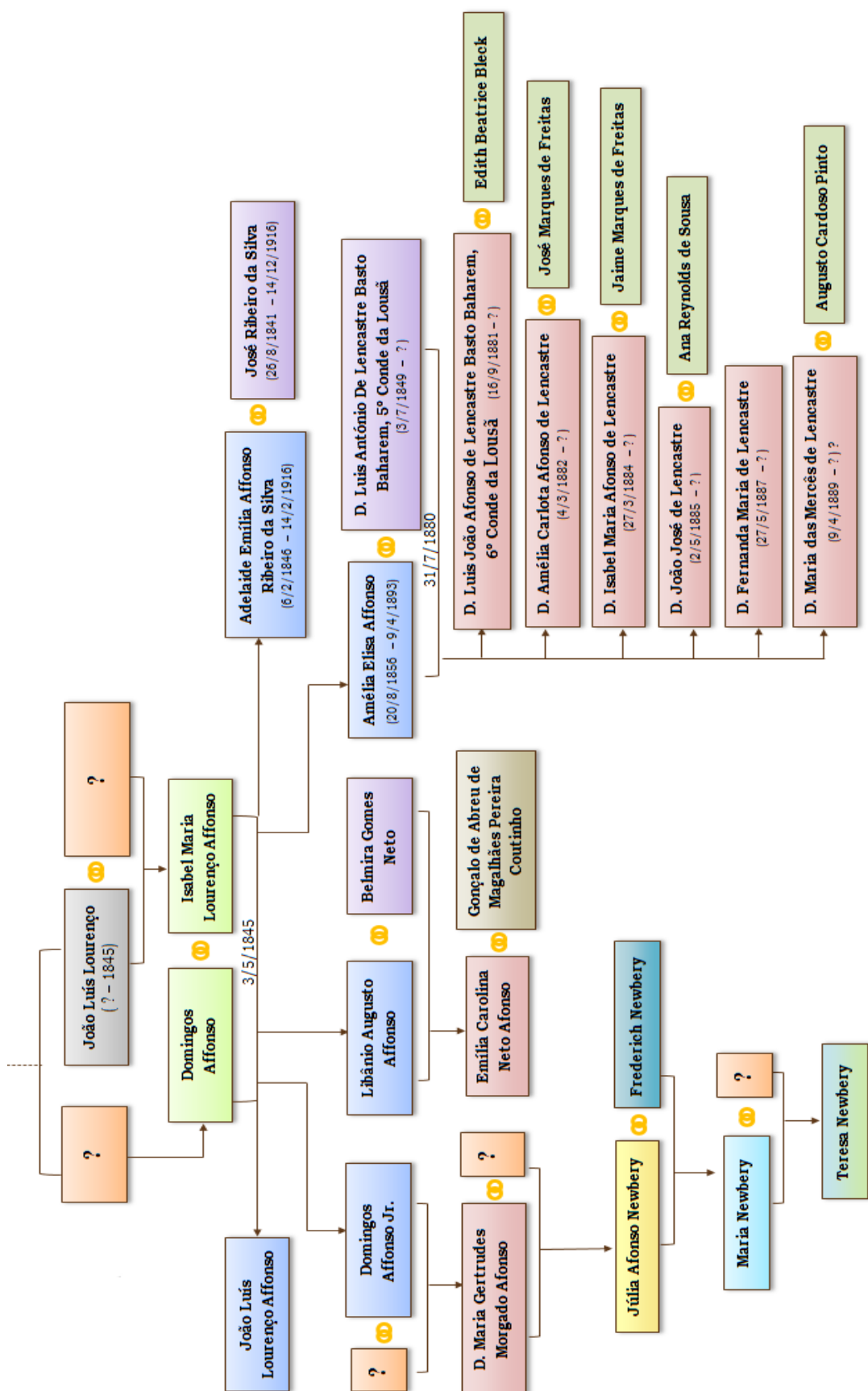
**Figure III.2** - Domingos Affonso, inverted letter at 550nm wavelength (top) with the script enhanced digitally (by writing on top) (bottom). The text says: "[...] Domingos Aff[onso] [Vice Consul dos Estados [U]ni[dos] da [Ame]rica. Aerialva." in brackets are assumed words.



**Figure III.1** - Domingos Affonso Portrait. The letter he is holding is highlighted in red.



# APPENDIX IV – GENEALOGICAL TREE



Information compiled from references: 2, 4, 5, 6, 7 and Cláudia Silveira (staff member from Ecomuseu Municipal do Seixal) personal communications, 2014.



## APPENDIX V – MAP OF DAMAGES



**Figure V.1** - Mapping of the painting condition.

## APPENDIX VI – MATERIAL ANALYSIS

### Appendix VI.1 – Instruments Description

All the analytical instruments used belong to FCT-DCR, with the exception of the SEM-EDX belonging to the Hercules Laboratory, University of Évora.

#### ➤ **Photographic Documentation**

Studio photographs were taken with a Sony digital camera (DSC-F828, Cyber-shot, Zeiss, Super HAD CCD, 4colour, 7x optical zoom, 8.0Mega-pixels). For photographs with Ultraviolet (UV) light, the camera was equipped with a UV filter (Hoya Pro1Digital Filter: Tokina Co., Ltd. DCM, 58) and for photographs with Infrared (IR) light with an IR filter (Hoya, 58mm Infrared R72). Other photographs taken to documentation throughout the treatment were acquired with a Samsung WB800F.

#### ➤ **X-radiograph**

The X-radiograph was taken using an ArtXRay from NTB elektronische Geraete GmbH digital system. This system is composed of a X-ray generator Y.MBS/160-F01, with a directional beam with a focal spot size of 1,9mm, a 40-160kV voltage, 0,2-5,0mA current and a maximum X-ray power of 480W; a manipulator of 4µm/step and 5000steps/revolution resolution; and a camera with 10-160kV radiation sensitive range, 0,083mm pixel size, and 12pixel/mm resolution.

For the X-radiographs the following conditions were used: 60 kV and 2,4 mA with 100ms of integration time. The digital images were acquired and processed with iX-Pect software.

#### ➤ **Optical Microscopy (OM)**

The optical microscope is an Axioplan 2ie Zeiss microscope equipped with a transmitted and incident halogen light illuminator (tungsten light source, HAL 100); UV light (mercury light source, HBO 100 illuminator); and a digital Nikon camera DXM1200F, with Nikon ACT-1 application program software, for microphotographs. Samples were analysed with 10x ocular lenses and 5x/10x/20x/50x objective Epiplan lenses (giving total optical magnification of 50x, 100x, 200x, and 500x).

For the incident and transmitted light (normal light) the samples were analysed under crossed polars – polariser and analyser filters; and for UV light the Zeiss filter set 2 [BP300-400, FT 395, LP 420] was used. The scales for all objectives were calibrated within the Nikon ACT-1 software.

#### ➤ **Energy Dispersive X-ray Fluorescence (µ-EDXRF)**

X-rayfluorescence spectra were obtained using an ArtTAX spectrometer from Intax GmbH. Operating with a molybdenum (Mo) X-ray tube, focusing polycapillary lens and silicon drift electro-thermally cooled detector and a xFlash (Si drift) detector, with 170 eV resolution. The accurate positioning system and polycapillary optics enable a small area of primary radiation ( $\varnothing \sim 70 \mu\text{m}$ ) at the sample. Elemental compositions were obtained from the average of three independent spots, analysed with a tube voltage of 40KV and a current intensity of 600µA and live time 100s.

#### ➤ **µ-Raman**

Micro-Raman microscopy was done using a Labram 300 Jobin Yvon spectrometer, equipped with a He-Ne laser of 17 mW power operating at 632.8 nm and an external laser of 50mW power operating at 532 nm. Spectra were recorded as an extended scan. The laser beam was focused with a 506 Olympus objective lens (50x). The laser power at the surface of the samples was varied with the aid of a set of neutral density filters (optical densities 0.3, 0.6, 1). The spectra are shown as acquired, without corrections or any further manipulations.

#### ➤ **Fourier Transform Infrared Spectroscopy (µ-FTIR)**



Infrared spectra were acquired using a Nicolet Nexus spectrophotometer coupled to a Continuum microscope (15xobjective) with a MCT-A detector cooled by liquid nitrogen. The spectra were collected in transmission mode, between 4000 – 650  $\text{cm}^{-1}$ , resolution setting 4  $\text{cm}^{-1}$  and 128 scans, using a Thermo diamond anvil compression cell. The spectra are shown as acquired, without corrections or any further manipulations, except for the removal of the  $\text{CO}_2$  absorption at ca. 2300-2400  $\text{cm}^{-1}$ .

➤ **Electron Scanning Microscopy with Energy Dispersive X-ray Spectroscopy (SEM-EDX)**

Variable pressure scanning electron microscope HITACHI 3700N coupled with energy dispersive X ray spectrometer: SEM-EDS BRUKER Xflash 5010SDD. The spectra were acquired with voltage of 20 kV, 23mm of working distance and present real time of 30s.

**Appendix VI.2 – Sampling areas for Cross-Sections (S),  $\mu$ -FTIR (F) and  $\mu$ -EDXRF points**



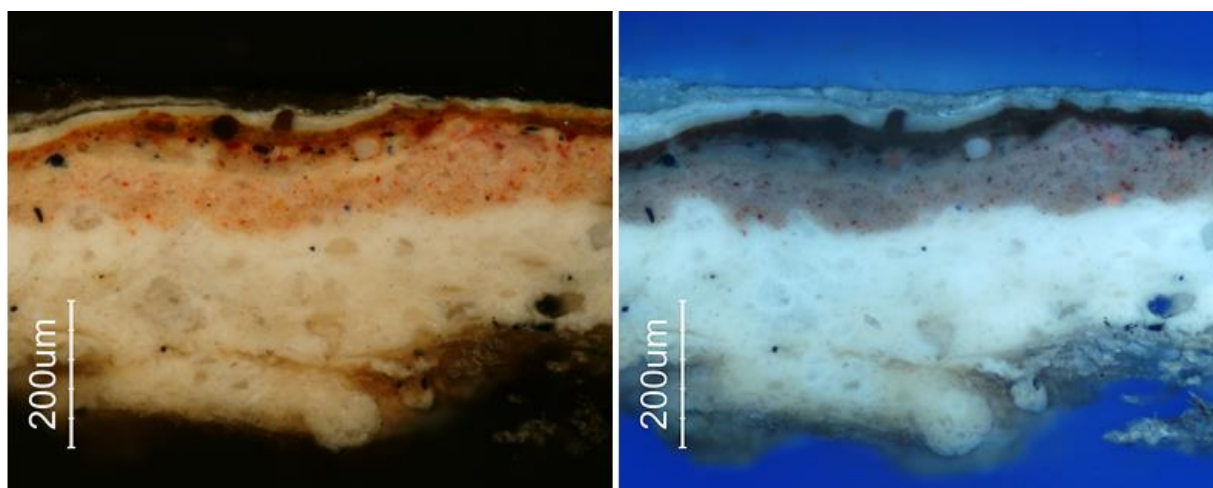
**Figure VI.1** - Sampling areas for Cross-Sections (S),  $\mu$ -FTIR (F) and  $\mu$ -EDXRF points (•).

**Table VI.1** - Code for identification of cross-sections (left) and  $\mu$ -FTIR (right) samples.

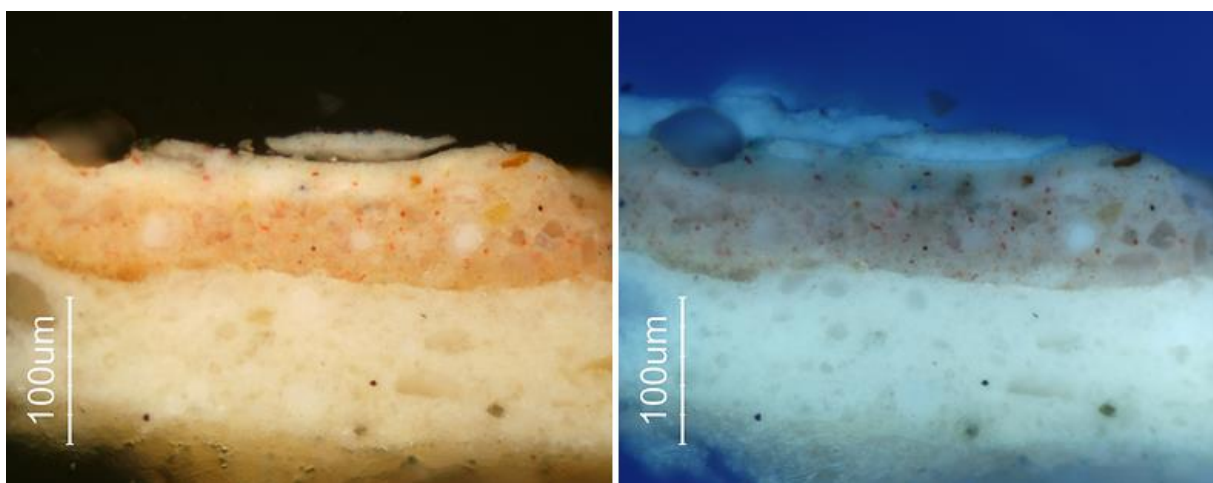
Sample	Colour / Area
S1	Medium Flesh tone (right hand)
S2	Light Flesh tone (right hand)
S3	Dark Flesh tone (shadow) (left hand)
S4	Background (right side of the figure)
S5	Background (right side of the figure)
S6	Background (left side of the figure)
S7	Light green (dress)
S8	Medium green (dress)
S9	Dark green (dress)

Sample	Area
F1	Varnish
F2	Inpainting
F3	Ground interstices
F4	Ground
F5	Lining adhesive

### Appendix VI.3 – Cross-Sections Normal and Ultraviolet light

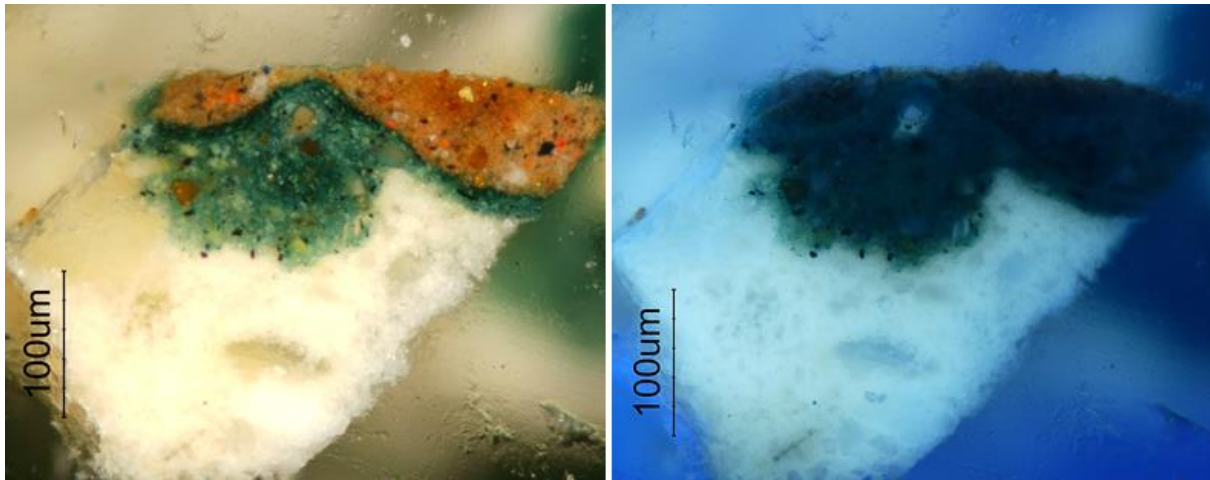


**Figure VI.2** - Cross-section S1, photographed with OM under Normal (left) and UV light (right).

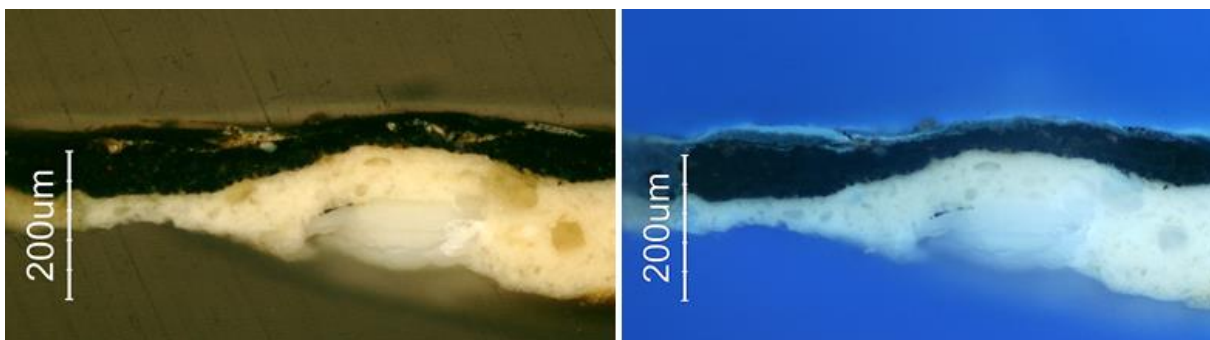


**Figure VI.3** - Cross-section S2, photographed with OM under Normal (left) and UV light (right).

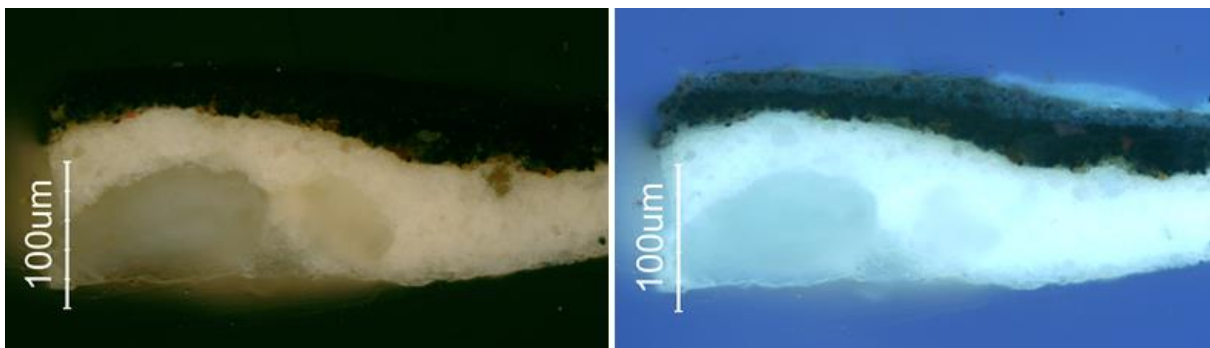




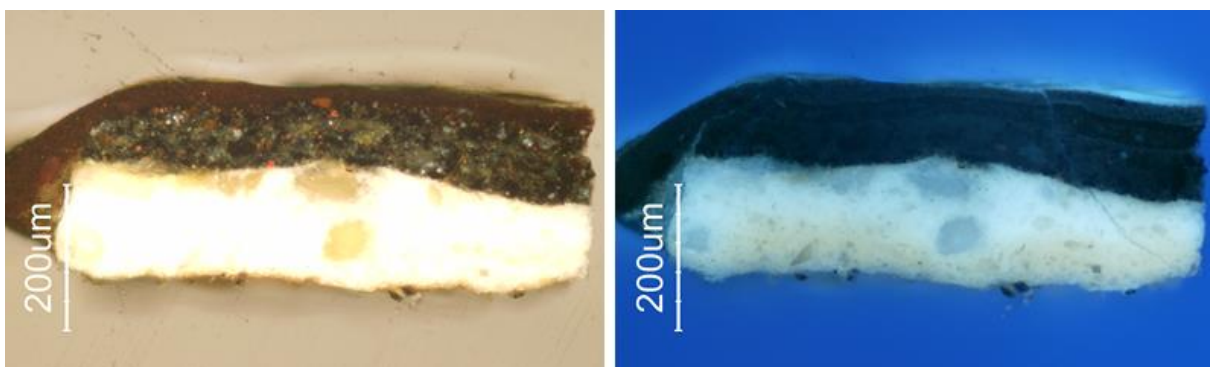
**Figure VI.4** - Cross-section S3, photographed with OM under Normal (left) and UV light (right).



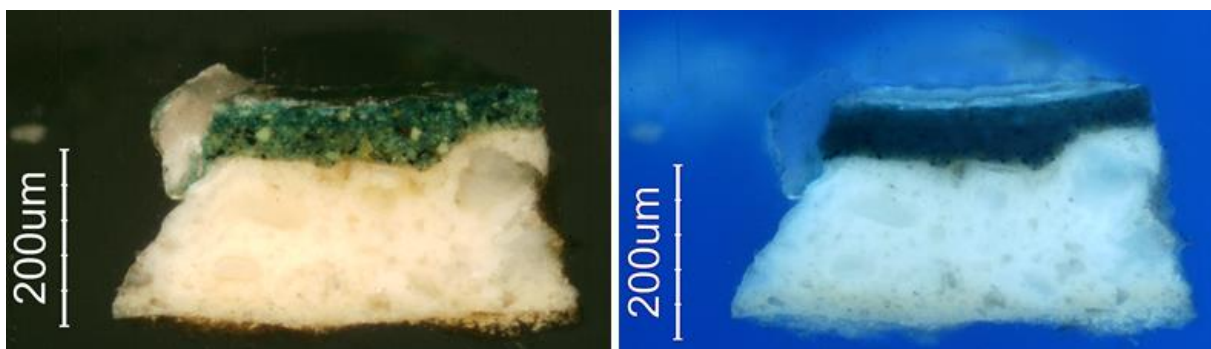
**Figure VI.5** - Cross-section S4, photographed with OM under Normal (left) and UV light (right).



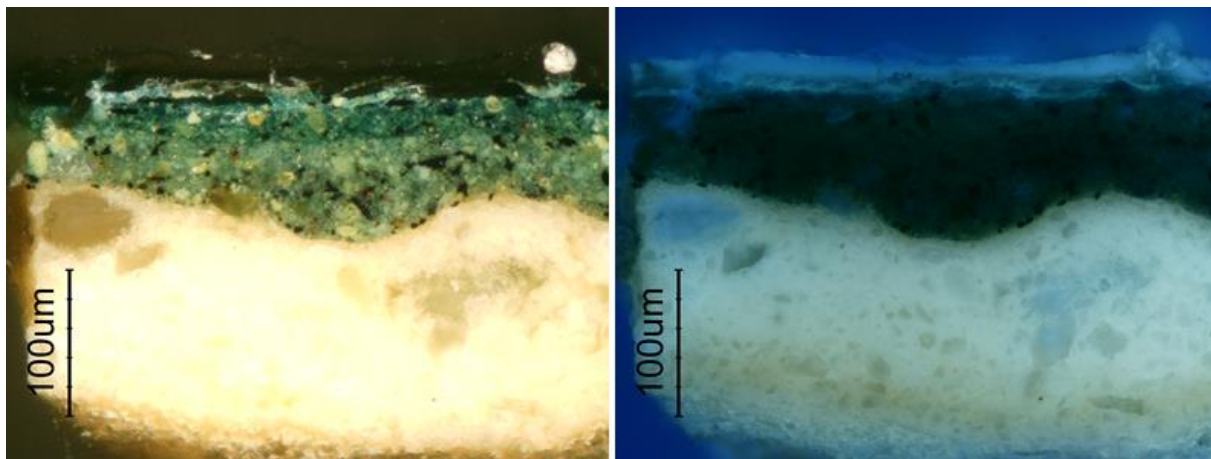
**Figure VI.6** - Cross-section S5, photographed with OM under Normal (left) and UV light (right).



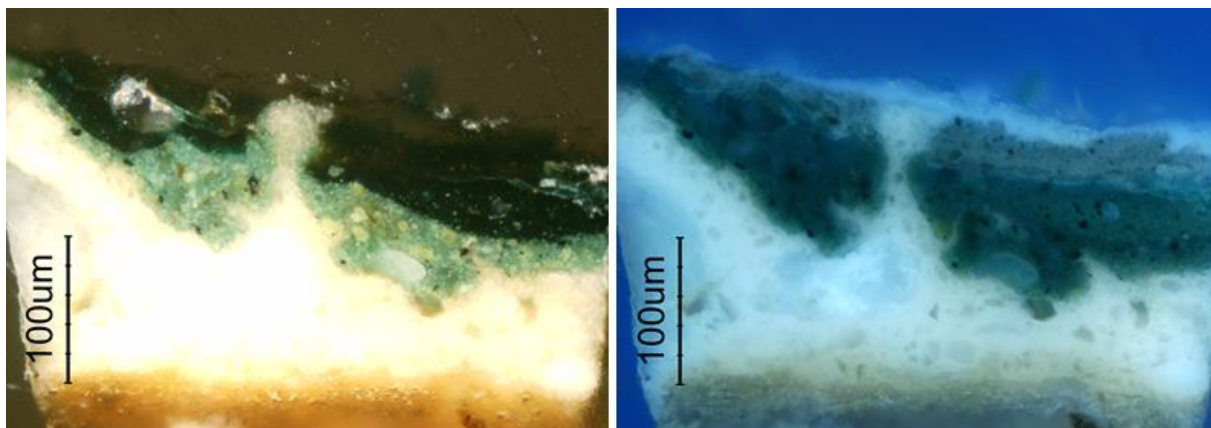
**Figure VI.7** - Cross-section S6, photographed with OM under Normal (left) and UV light (right).



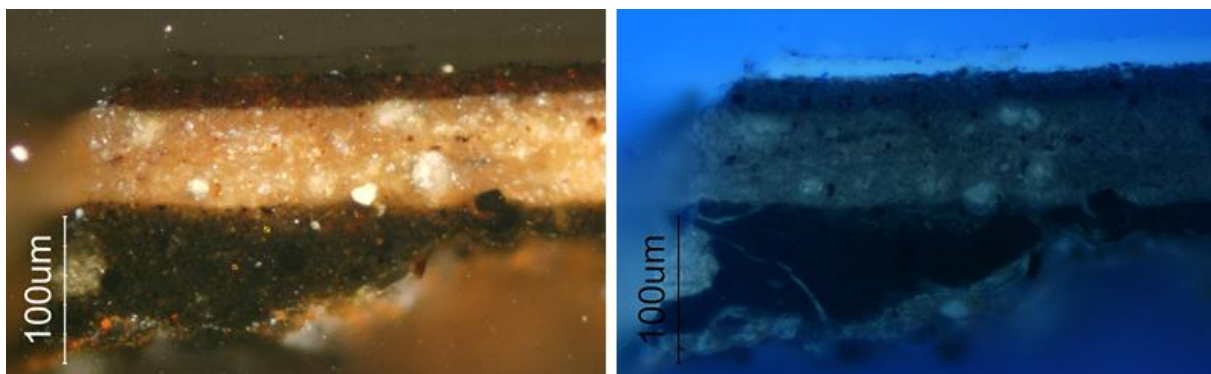
**Figure VI.8** - Cross-section S7, photographed with OM under Normal (left) and UV light (right).



**Figure VI.9** - Cross-section S8, photographed with OM under Normal (left) and UV light (right).



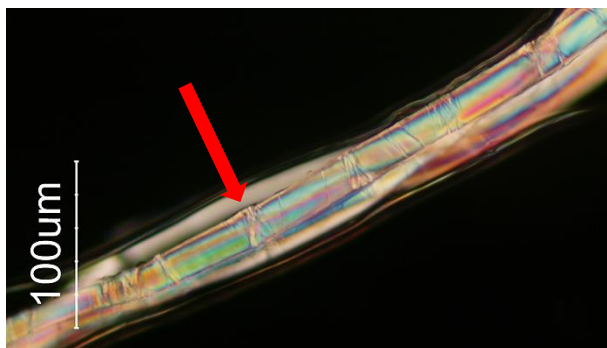
**Figure VI.10** - Cross-section S9, photographed with OM under Normal (left) and UV light (right).



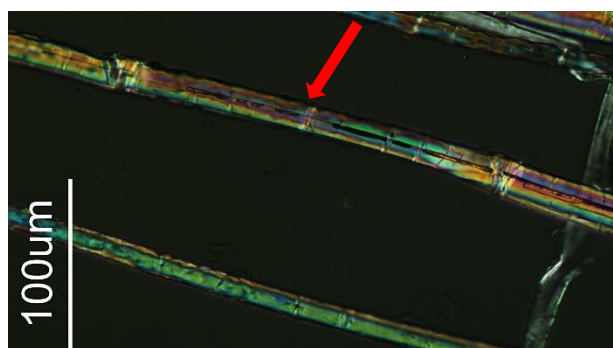
**Figure VI.11** - Cross-section S10, photographed with OM under Normal (left) and UV light (right).

#### **Appendix VI.4 – Fibre Identification: original and lining canvas from *Isabel Affonso***

Through OM observation it was possible to assign both fibres (from original and lining canvas) as bast fibres, likely flax fibres. During the 18th and 19th centuries the main painting support fabrics were hemp and linen [12].

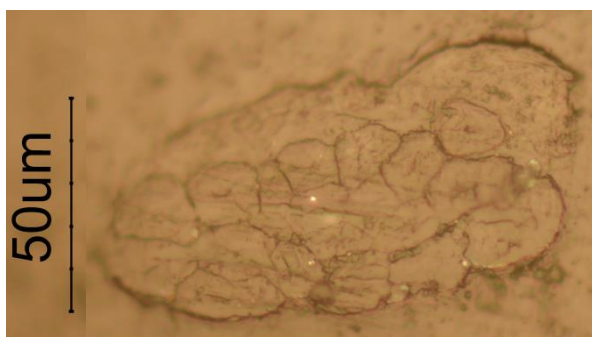


**Figure VI.12** - Longitudinal view of a fibre from the original canvas under OM: cross polarised light, total magnification 200x. The red arrow indicates a cross-marking (x shaped).



**Figure VI.13** - Longitudinal view of a fibre from the lining canvas under OM: cross polarised light, total magnification 200x. The red arrow indicates a cross-marking (x shaped).

The longitudinal view of both fibres (Fig. AVI.12 and AVI.13), shows characteristic cross markings (mainly x shaped joint-like, also transverse cross marks, bulges and even nodules) along the fibre [7,12], and a rainbow interference colours (under cross polarised light) that are typical of bast fibres [12]. The overall appearance (size, shape, taper pointed end) are consistent with flax or hemp fibres, however due to their subtle differences it is not always possible to distinguish them.



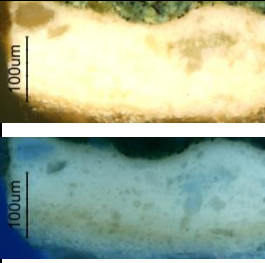
**Figure VI.14** - Transverse view of a fibre from the original canvas.

In an attempt to distinguish these two types of fibres a cross section was made (Fig. AVI.14). And the transverse view seems to corroborate the idea that it is a flax fibre due to the polygonal shape and slightly rounded outline of the fibres wall of the cell, and the oval elongated lumen.

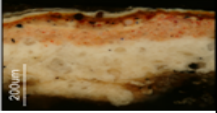
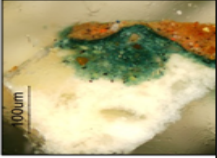


## Appendix VI.5 – Pigments Identification Table

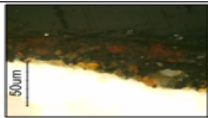
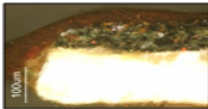
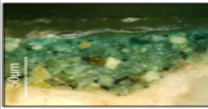
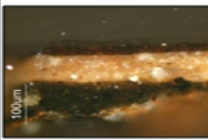
**Table VI.2** - Pigment analysis from the Female ground.

Female							
Sample	$\mu$ -EDXRF	SEM-EDX	$\mu$ -Raman		$\mu$ -FTIR		Identified Pigments
			Wavenumber (cm <sup>-1</sup> )	Assignment	Wavenumber (cm <sup>-1</sup> )	Assignment	
 <p>Ground</p> <p>Normal and UV light image from Cross-Section S8 ground layers.</p>	(K), Ca, Ba, (Mn), Fe, (Cu), Pb	Ca, S	416m 1008vs; 1136m	- $\nu_s(\text{SO}_4^{2-})$	3550m; 3487w; 3406s 3243w 1622m 1135vs; 1117vs 1003w 672m	$\nu$ (HO) $\delta$ (H <sub>2</sub> O) $\delta$ (O-H-O) (H <sub>2</sub> O) $\nu_{as}(\text{SO}_4^{2-})$ $\nu_s(\text{SO}_4^{2-})$ $\delta_{as}(\text{SO}_4^{2-})$	Calcium Sulfate Dihydrate (Gypsum) $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
		Pb, C, O	1050vs-1054s	$\nu_s(\text{CO}_3^{2-})$	3533w 1405vs 832vw 682s	$\nu$ (OH) $\nu_{as}(\text{CO}_3^{2-})$ $\delta_{\text{out-of-plane}}(\text{CO}_3^{2-})$ $\delta_{\text{in-plane}}(\text{CO}_3^{2-})$	Lead White $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$
		Ba, S, O, Pb	459m 987s	- $\nu_s(\text{SO}_4^{2-})$	1178m; 1112s; 1082vs 981w	$\nu_{as}(\text{SO}_4^{2-})$ $\nu_s(\text{SO}_4^{2-})$	Barium Sulfate $\text{BaSO}_4$

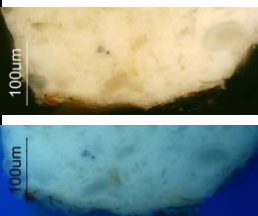
**Table VI.3** - Pigments identified in the Female paint layers.

Female						
Sample	$\mu$ -EDXRF	SEM-EDX	$\mu$ -Raman		Identified Pigments	
			Wavenumber (cm <sup>-1</sup> )	Assignment		
 <p>S1 and S2 - Flesh Paint</p>	(K), Ca, Ba, Mn, Fe, Cu, Hg, Pb, (As?)	Pb, C, O	1049s-1053s		Lead White $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$	
		Ba, S, O, Pb	460m, 988s		Barium Sulfate $\text{BaSO}_4$	
		-	253vs; 283w 343m	$\delta$ (S-Hg-S) $\nu$ (Hg-S)	Vermilion $\text{HgS}$	
		-	1325vs (br) 1590vs (br)	$sp^3$ (C-C) $sp^2$ (C-C)	Carbon Black	
		Fe, Pb, Si, Ca, Al, Mg, S, K, Ti	241vw 297w; 477vw 555w	392vs, $\delta_s(\text{Fe-O})$ $\delta_{as}(\text{Fe-O})$ $\nu_{as}(\text{Fe-O})$	Goethite $\alpha\text{-FeOOH}$	
		Fe, Pb, Mg, Ca	224vs 251w 291-299vs, 408m 610w 1314m (br)	- $\delta_s(\text{Fe-O})$ $\delta_{as}(\text{Fe-O})$ $\nu_s(\text{Fe-O})$ -	Hematite $\alpha\text{-Fe}_2\text{O}_3$	
		Si, Al, Na, S, Pb, K, Cl, Fe	257w 548vs 815w 1098m	$\delta$ (S <sub>3</sub> ) $\nu_s$ (S <sub>3</sub> ) - overtone	Ultramarine Blue (probably the synthetic form) $\text{Na}_3[\text{Al}_6\text{Si}_6\text{O}_{24}]\text{S}_n$	
		Al, C, Si, K, Ca	-	-	Lake pigment ?	
 <p>S3 - Flesh Paint shadow (green paint underneath)</p>	(K), Ca, Ba, (Mn), Fe, Cu, Hg, Pb	Pb, Al, Fe, Si, S, K, Na, Ca, Cu, P, Mg, Ti, Cl	145vs 258w, 548vs 822w, 1096m 1355vw, 1647vw		Terre-verte $\text{K}[(\text{Al}^{\text{III}}, \text{Fe}^{\text{III}})(\text{Fe}^{\text{II}}, \text{Mg}^{\text{II}})]_2(\text{AlSi}_2\text{Si}_4\text{O}_{10})(\text{OH})_2$ ? Ultramarine Blue (probably the synthetic form) $\text{Na}_3[\text{Al}_6\text{Si}_6\text{O}_{24}]\text{S}_n$	
		Pb, Sb, O, Al, Fe, Na, Si	140vs	-	Naples yellow $\text{Pb}_2\text{Sb}_2\text{O}_7$ ?	
		Pb, C, O, As, S, Fe, Si, K, Cl, Na, Al, Ca	136w 154m 179vw 202w, 292m 309s, 353vs 358w (sh) 380w	$\delta$ (S-As-S) - $\delta$ (S-As-S) $\nu$ (As-S) - -	Orpiment $\text{As}_2\text{S}_3$	
		Fe, Pb, Na, Si, Al, Ca	240vw, 297m 395vs, 476vw, 553w 276w, 532s, 2092w, (sh), 2153vs	- $\delta$ (C-Fe-C) $\delta$ (Fe-C $\equiv$ N) $\nu$ (C $\equiv$ N)	Goethite $\alpha\text{-FeOOH}$ Prussian Blue $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$	
		-	253vs, 343m	-	Vermilion $\text{HgS}$	
		-	1331vs (br), 1589vs (br)	-	Carbon Black	
		Pb	1049s, 1051s	-	Lead White $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$	
		-	460m, 988s	-	Barium Sulfate $\text{BaSO}_4$	


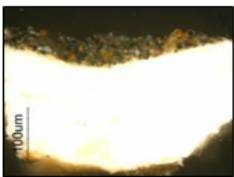
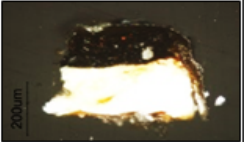



S4, S5 e S6 – Background		(K), Ba, Fe, (Hg), As, Ca, (Mn), Cu, Pb	-	241vw, 298m 393vs, 550w	-	Goethite $\alpha\text{-FeOOH}$
			As, Cu, Si, Fe, Pb	117w, 153vs, 171w, 214vs, 243m, 321m, 365m, 490m, 537m; 948m	- $v_s(\text{C-C})$	Emerald Green $\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 3\text{Cu}(\text{AsO}_2)_2$
			-	253vs, 280w, 343m	-	Vermilion $\text{HgS}$
			-	1325vs (br), 1590vs (br)	-	Carbon Black
			-	1048-1052s	-	Lead White $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$
			-	452w, 988s	-	Barium Sulfate $\text{BaSO}_4$
S6 – top layer (mainfillin)		(K), Ca, (Ba), Mn, Fe, Cu, Zn, Pb	C, Si, Fe, Al, Na, Pb, K, Ca, Mg	257w, 547vs, 812w, 1093m	-	Ultramarine Blue (probably the synthetic form) $\text{Na}_3[\text{Al}_6\text{Si}_6\text{O}_{24}]\text{S}_n$
S7, S8 e S9 – Dress, green colour		(K), Ca, Ba, (Mn), Fe, Cu, (Hg), Pb, As	Ca, Pb, Al, Si, S, P, K, Ba, Fe, Na, Mg	145vs, 510m, 636m, 680w	-	Terre-verte $\text{K}[(\text{Al}^{III}, \text{Fe}^{III})_3(\text{Fe}^{II}, \text{Mg}^{II})]_2(\text{AlSi}_3\text{Si}_4\text{O}_{10})(\text{OH})_2 ?$
			C, Al, Pb, Fe, Si, K, Na, S, Cu, Ca, P	274w, 533s, 2094w, 2125w (sh), 2155vs	-	Prussian Blue $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$
			Pb, Sb, Si, Fe, Al, Na, Mg	140vs, 290s	-	Naples yellow $\text{Pb}_2\text{Sb}_2\text{O}_7 ?$
			Ba, S, Pb, Mg, Al, Na, Si, Fe, Ca, K	450m, 461w, 616w, 987vs	-	Barium Sulfate $\text{BaSO}_4$
				1048-1051s	-	Lead White $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$
			-	298m, 398s 478vw, 547w	-	Goethite $\alpha\text{-FeOOH}$
			-	252vs, 282w (sh), 342m	-	Vermilion $\text{HgS}$
			-	1331vs (br), 1589vs (br)	-	Carbon Black
S10 – Infill Background		(K), Ca, (Ba), Mn, Fe, (Cu), (Zn?), Pb	C, Ca, Fe, Pb, Si, Al, Mg, Mn, S	1085vs	-	Calcium Carbonate $\text{CaCO}_3$
			-	1326vs (br) 1591vs (br)	-	Carbon Black
			Si, Al, S, Fe, Na, Ca, K, Cd, Mg, Mn	259w, 547vs 812w, 1092m	-	Ultramarine Blue (probably the synthetic form) $\text{Na}_3[\text{Al}_6\text{Si}_6\text{O}_{24}]\text{S}_n$

**Table VI.4** - Pigment analysis from the Male ground.

Male							
Sample	$\mu\text{-EDXRF}$	SEM-EDX	$\mu\text{-Raman}$		$\mu\text{-FTIR}$		Identified Pigments
			Wavenumber ( $\text{cm}^{-1}$ )	Assignment	Wavenumber ( $\text{cm}^{-1}$ )	Assignment	
<b>Ground</b>  Normal and UV light image from Cross-Section S3 ground layers.	(Ca), Ba, (Mn), Fe, (Cu), Pb	C, Ca	1085vs	$v_s(\text{CO}_3^{2-})$	-	-	Calcium Sulfate Dihydrate (Gypsum) $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
		Pb, C, O	1050vs-1054s	$v_s(\text{CO}_3^{2-})$	3534w 1401vs 835vw 682s	$v(\text{OH})$ $v_{\text{as}}(\text{CO}_3^{2-})$ $\delta_{\text{out-of-plane}}(\text{CO}_3^{2-})$ $\delta_{\text{in-plane}}(\text{CO}_3^{2-})$	Lead White $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$
		Ba, S, O, Pb	459m 987s	- $v_s(\text{SO}_4^{2-})$	1176m; 1113s; 1083vs 982w	$v_{\text{as}}(\text{SO}_4^{2-})$ $v_s(\text{SO}_4^{2-})$	Barium Sulfate $\text{BaSO}_4$

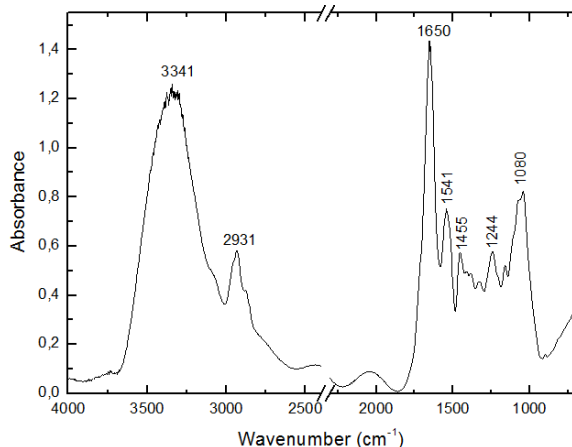
**Table VI.5** - Pigments identified in the Male paint layers.

Male						
	Sample	$\mu$ -EDXRF	SEM-EDX	$\mu$ -Raman		Identified Pigments
				Wavenumber (cm <sup>-1</sup> )	Assignment	
S4 - Flesh Paint (Left hand)		(K), (Ca), Ba, (Mn), <b>Fe</b> , Cu, Hg, <b>Pb</b>	C, Pb, Fe, Al, S, Si, Ca, Cu, P, K	1048s-1052s	-	Lead White 2PbCO <sub>3</sub> .Pb(OH) <sub>2</sub>
				460m, 988s	-	Barium Sulfate BaSO <sub>4</sub>
				253vs; 282w 342m	$\delta$ (S-Hg-S) $\nu$ (Hg-S)	Vermilion HgS
				1325vs (br) 1582vs (br)	$sp^3$ (C-C) $sp^2$ (C-C)	Carbon Black
				244vw 298w; 397vs, 478vw 551w	- $\delta_s$ (Fe-O) $\delta_{as}$ (Fe-O) $\nu_{as}$ (Fe-O)	Goethite $\alpha$ -FeOOH
				-	-	Lake pigment ?
S3 e S7 – Background		Ca, Ba, (Mn), <b>Fe</b> , Cu, (Hg), <b>Pb</b>	Pb, Ba, Fe, As, Cu, S, Al, Si, Ca, P, K	243vw, 298m 393vs, 555w	-	Goethite $\alpha$ -FeOOH
				223vs 291-299vs, 408m 611w	$\delta_s$ (Fe-O) $\delta_{as}$ (Fe-O) $\nu_s$ (Fe-O)	Hematite $\alpha$ -Fe <sub>2</sub> O <sub>3</sub>
				253vs, 280w, 343m	-	Vermilion HgS
				1325vs (br), 1590vs (br)	-	Carbon Black
				276w 531s 2093w; 2128w (sh); 2154vs	$\delta$ (C-Fe-C) $\delta$ (Fe-C $\equiv$ N) $\nu$ (C $\equiv$ N)	Prussian Blue Fe <sub>4</sub> [Fe(CN) <sub>6</sub> ] <sub>3</sub>
				1048-1052s	-	Lead White 2PbCO <sub>3</sub> .Pb(OH) <sub>2</sub>
				452w, 988s	-	Barium Sulfate BaSO <sub>4</sub>
				-	-	Orpiment As <sub>2</sub> S <sub>3</sub> ?
				-	-	Emerald Green Cu(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ).3Cu(As O <sub>2</sub> ) <sub>2</sub> ?
				1326vs (br), 1580vs (br)	-	Carbon Black
S5 – Black Jacket		Ca, (Ba), (Mn), <b>Fe</b> , Cu, (Hg), <b>Pb</b>	Ca, Pb, P, Fe, Ba, Hg, Al, Si, Cu, Mg, S, As, P, K	276w, 531s, 2091w, 2123w (sh), 2154vs	-	Prussian Blue Fe <sub>4</sub> [Fe(CN) <sub>6</sub> ] <sub>3</sub>
				245vw, 298m, 395s 478vw, 553m	-	Goethite $\alpha$ -FeOOH
				252vs, 282w (sh), 342m	-	Vermilion HgS
				1049-1053s	-	Lead White 2PbCO <sub>3</sub> .Pb(OH) <sub>2</sub>
				451m-461m, 617w, 646w, 988vs	-	Barium Sulfate BaSO <sub>4</sub>
				-	-	-
S9 – Infill Background		(K), Ca, (Mn), <b>Fe</b> , (Cu), (Zn), <b>Pb</b>	C, Ca, Si, Mg, Al	1085vs	-	Calcium Carbonate CaCO <sub>3</sub>
			-	1326vs (br) 1591vs (br)	-	Carbon Black
			Si, Al, S, Fe, Na, Ca, K, Cd, Mg, Mn	258w, 548vs 820w, 1093m	$\delta$ (S <sub>3</sub> <sup>-</sup> ) $\nu_s$ (S <sub>3</sub> <sup>-</sup> ) - overtone	Ultramarine Blue (probably the synthetic form) Na <sub>8</sub> [Al <sub>6</sub> Si <sub>6</sub> O <sub>24</sub> ]S <sub>n</sub>

## Appendix VI.6 – $\mu$ -FTIR spectra analysis

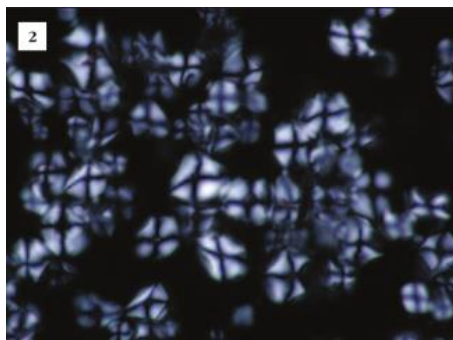
### ➤ Old lining adhesive analysis

In the spectrum (Fig. VI.15) protein was observed by the amide group (-NH-CO-) stair-step pattern: with the amide I band at  $1653\text{cm}^{-1}$  (C=O stretching), amide II band at  $1541\text{cm}^{-1}$  (N-H bending and C-N stretching) and amide III at  $1455\text{cm}^{-1}$  (C-H bending). Amide presence was also confirmed by the  $3341\text{cm}^{-1}$  band (N-H stretching). The remaining spectrum bands can be attributed to a polysaccharide by the broad bands about  $1080\text{cm}^{-1}$  (C-O stretching) and  $3341\text{cm}^{-1}$  (O-H stretching) [42,43].

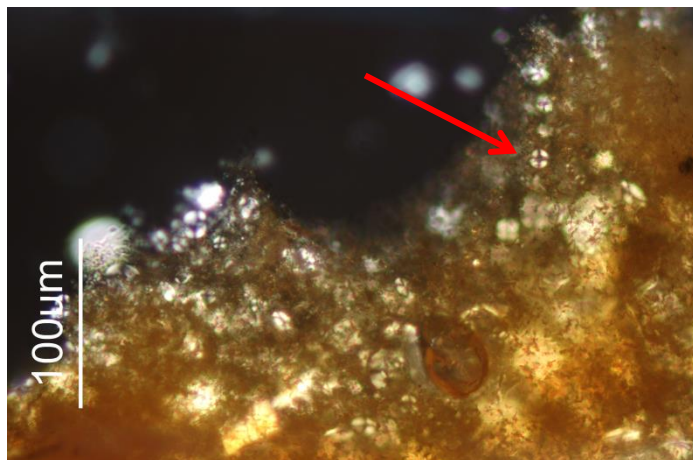


**Figure VI.15** -  $\mu$ -FTIR spectrum of an old lining adhesive sample.

A sample of old lining adhesive collected during its removal from the back of the painting was observed with Polarised Light Microscopy (PLM). Under crossed polars, starch grains show distinct extinction crosses, often symmetrical [44]. The characteristic aspect can be seen in Fig. VI.17 (an example is marked with a red arrow). A comparison reference image is showed in Fig. VI.16.



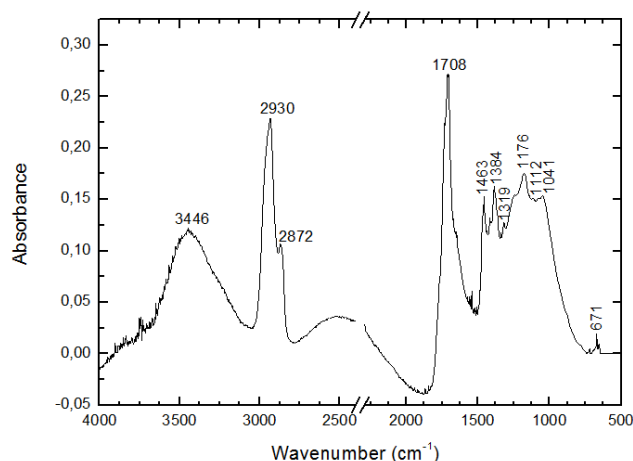
**Figure VI.16** - Reference image for starch under crossed polars. Image from *The Pigment Compendium*, p. 894 [44]



**Figure VI.17** - OM image of an old lining adhesive sample under cross polarised light, where characteristic starch centred extinction crosses are visible (red arrow pointing at one).

### ➤ Varnish analysis

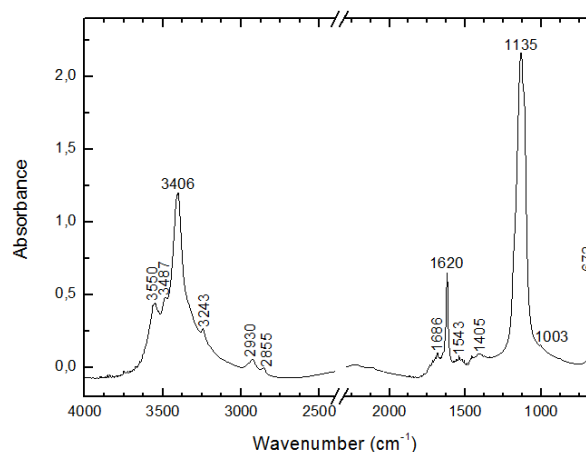
The cyclic ring structure, from triterpenoid resins, produces two strong and distinct bands at  $2930\text{cm}^{-1}$  and  $2872\text{cm}^{-1}$  (C-H stretching, asymmetric and symmetric respectively) and a strong carbonyl stretch at  $1708\text{cm}^{-1}$ . The remaining bands in the spectrum also belonging to the varnish are between  $1463$  and  $1319\text{cm}^{-1}$  (C-H bending), between  $1176$  and  $1041\text{cm}^{-1}$  (C-O stretching) and at  $3446\text{cm}^{-1}$  (O-H stretching) [42,43] (Fig. VI.18).



**Figure VI.18** -  $\mu$ -FTIR spectrum of a varnish sample.

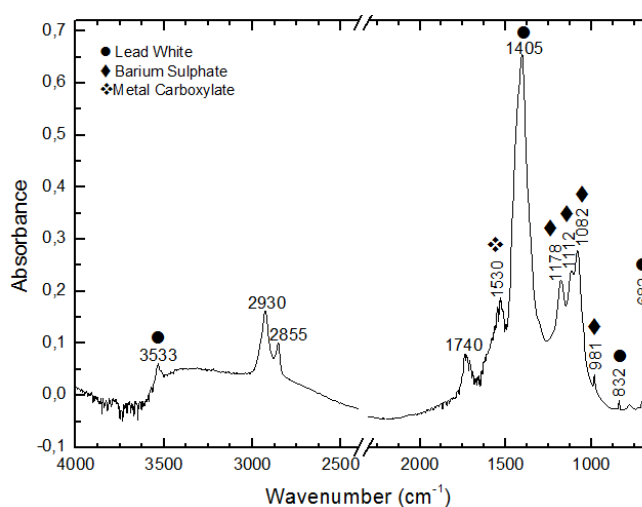
### ➤ Ground analysis

$\mu$ -FTIR analysis of a ground sample removed from the interstices of the canvas, showed characteristic bands of gypsum (calcium sulfate dihydrated,  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) at 3350, 3487, 3406, 3243, 1622, 1135, 1117, 1003, 672  $\text{cm}^{-1}$  (see Table VI.2 for assignments). The binding medium used, although masked by the inert material, appears to be oil, visible in the  $\mu$ -FTIR spectrum by the asymmetric and symmetric stretching modes of  $\text{CH}_2$  groups at 2930  $\text{cm}^{-1}$  and 2854  $\text{cm}^{-1}$ , respectively. However confirmation is not possible without the carbonyl band [39] (Fig. VI.19).



**Figure VI.19** -  $\mu$ -FTIR spectrum of a ground sample from interstices of the canvas

The components of the second ground layer, immediately below the paint layers, are lead white ( $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$ ) and barium sulfate ( $\text{BaSO}_4$ ) with an oil binder. Evident in the  $\mu$ -FTIR spectrum (Fig. 57) where characteristic bands of an aged drying oil appear at 2930 and 2855  $\text{cm}^{-1}$  ( $\text{CH}_2$  stretch); at 1740  $\text{cm}^{-1}$  ( $\text{C}=\text{O}$ ) from the ester bond and carboxylic acid and at 1530  $\text{cm}^{-1}$  from the metal carboxylates [45, 46, 47]. The assignments for lead white and barium sulfate bands (marked in the fig. VI.20) are in the Pigment Identification Table VI.2.



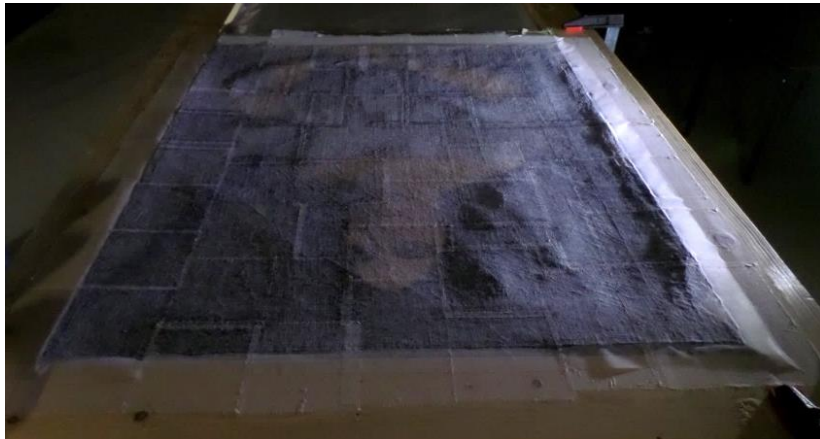
**Figure VI.20** -  $\mu$ -FTIR spectrum of a ground sample.



APPENDIX VII – TREATMENT PHOTOGRAPHS



**Figure VII.1** – Painting with the facing.



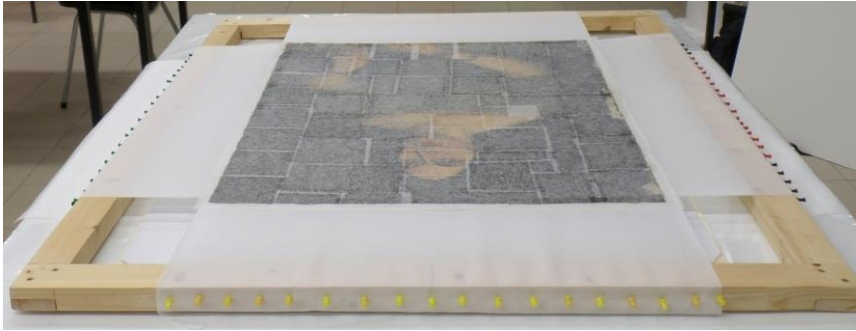
**Figure VII.2** - Raking light photograph, showing the facing tissue conformation to the painting distortions.



**Figure VII.3** - Lining canvas mould and water damage visible after the stretcher removal.



**Figure VII.4** - Lining canvas debris: dust and a boring insect case.



**Figure VII.5** - Painting on the strip loom, face side up (allows working on the back).



**Figure VII.6** - Painting on the strip loom, back side up (allows working on the front).



**Figure VII.8** - Moist, NaCMC and Tylose tests. Showing the saturated canvas (indicating adhesive penetration into the canvas interstices) mainly from the moist blotting paper test is a red arrow.



**Figure VII.7** - Dremel and adapted dimmer switch.



**Figure VII.9** – Detail of the good results, achieved by removing of concrete old adhesive with Dremel.



**Figure VII.10** - Detail of the canvas fabric, with removed adhesive on the right side (no damage appear to be caused in the fibres), and concrete adhesive still present on the left side.

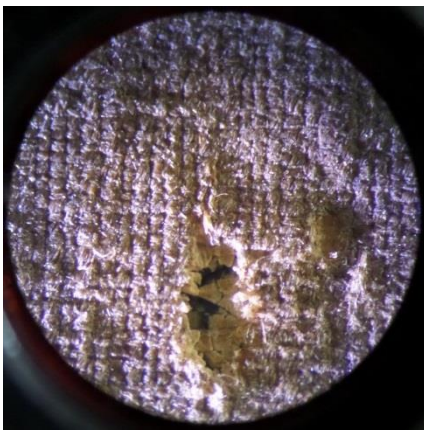




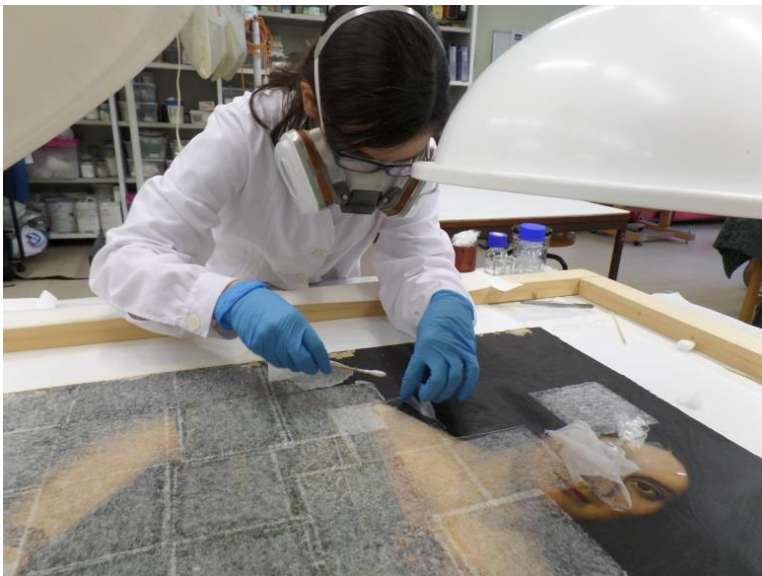
**Figure VII.11** - Removal of the concrete old adhesive with the Dremel.



**Figure VII.12** – Before (left) and after (right) the old adhesive removal.



**Figure VII.13** - Consolidation of the original canvas. Fabric loss before (left) and after (right) consolidation.



**Figure VII.14** - Facing removal with solvent, hence the mask and extractors above the painting.



**Figure VII.15** – Shoulder cleaning test.



**Figure VII.16** – Transparent brown glaze that appears to be painted on the corset, creating a floral pattern.



**Figure VII.17** – Before (left) and after (right) varnish cleaning on the bottom edge of the painting.



**Figure VII.18** – Plastic conformation to the paint surface under vacuum.

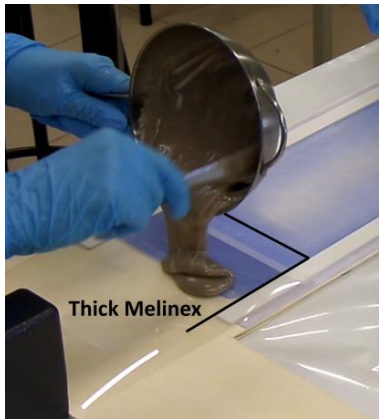


**Figure VII.19** – A line of Duplosil® being applied with a syringe onto the white plastic strips.



**Figure VII.20** – Duplosil® mould levelling with an 8ply matt-board applicator.

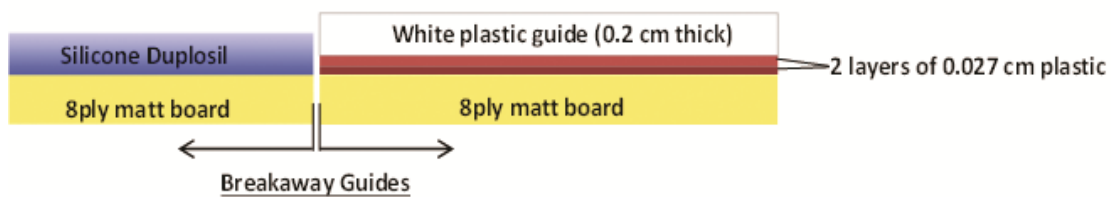




**Figure VII.21** – Piece of thick Melinex® used to pour the BGP without affecting the silicone mould.



**Figure VII.22** – BGP application on top of the silicone mould to create a textured replacement strip.



**Figure VII.23** – Diagram of the “Break away” guides design.

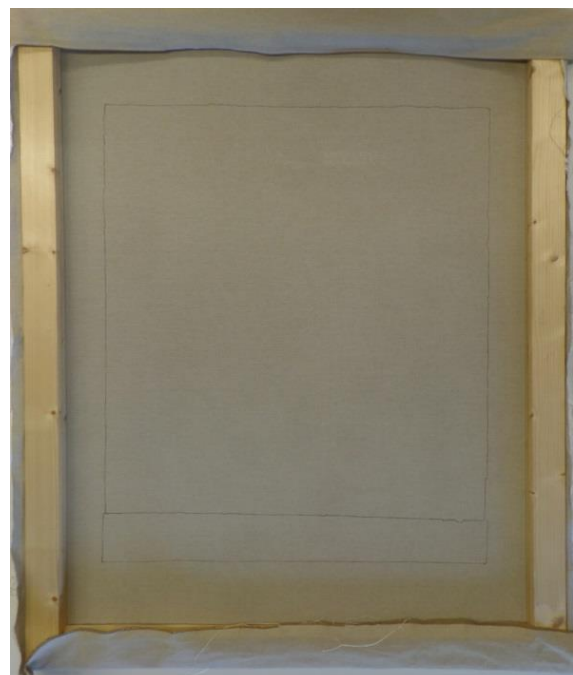


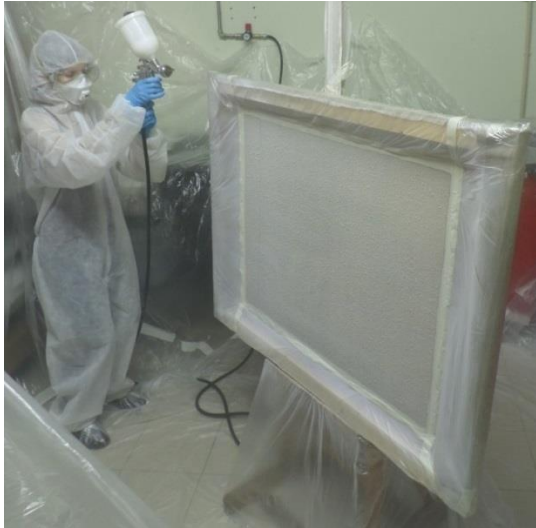
**Figure VII.24** – Final BGP textured replacement strip. Prior to cuts and adjustments.



**Figure VII.25** – Small imperfections (holes) in the strip, that had to be locally filled and shaped.

**Figure VII.26** – Contours of the painting and replacement strip, registered in the lining canvas.





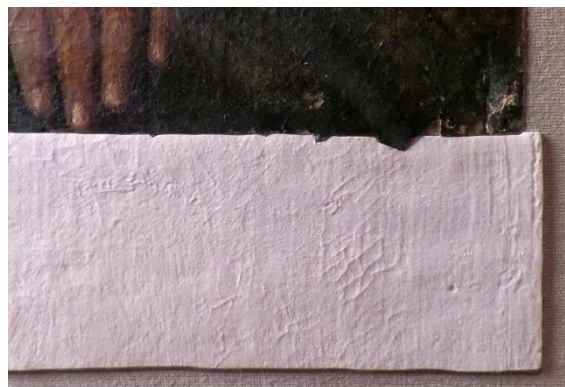
**Figure VII.27** – Adhesive spraying onto the lining canvas.



**Figure VII.28** – Detail of the fibres surface, from the lining fabric, after the adhesive application.



**Figure VII.29** – Lining process.



**Figure VII.31** – Detail of the strip, showing the edge between paint and strip, and the texture after the lining (implicating that no texture was lost during the process).

**Figure VII.30** – *Isabel Affonso* after the lining.

## APPENDIX VIII – EXPLORATION OF ENZYMES FOR THE OLD LINING ADHESIVE REMOVAL

Enzymes have been used in different conservation fields to remove old adhesives [12,48, 49], the choice of enzyme would be based on the type of adhesive, for example  $\alpha$ -amylase has been used to remove starch adhesive from textiles and was proved to be effective in that context, however most of the literature refers the necessity of rinsing the solution with a distilled water baths to remove residues, something that unlike in textile or paper conservation, cannot be done with a painting due to the complex system of different layers present. This concern of removability by baths of the enzyme solution is not discussed by Durel [48] in his use of a highly-purified amylase solution (very low concentration of enzymes, 0.05 mg/mL, applied in a blotter paper for twice 20 minutes) to degrade starch from a starch and protein based old lining adhesive, where the removal of the glue was then made with mechanical tweezers [48] even though encouraging results were ensured.

A meeting with Professor Alice Pereira<sup>28</sup> explored these issues and how enzymes are generally used in an aqueous solution and as biological catalysts they will denature or rendered inactive depending on certain factors (pH, temperature specific ion concentrations) [12]. Also in theory they could be removed by osmosis with *Mili-Q* water from the back of the canvas, but it is hard to ensure 100% removal.

So, as wisely pointed by Professor Alice Pereira, the use of enzymes would require a lot of parallel tests and investigations until determine their potential and safety to be used in this painting. Variables (enzyme concentration, temperature, pH, etc.) would have to be thoughtfully tried and time would be a strong factor.

## APPENDIX IX – REPLACEMENT STRIP

### **Appendix IX.1 – Casting the texture mould**

To cast the painting surface texture the first idea was to use a silicone mould material. However a small test with Duplosil® showed that it permanently stained a porous test surface therefore could not be safely used directly on top of the painting. A search of alternative mould materials that could be easily lifted off the surface without leaving residues behind was made. An important issue also taken into consideration was that the infill material chosen sticks to most surfaces so water-soluble materials were favourable since in theory the mould could be washed of the BGP strip.

Although the experimented materials (Table 4) had potential, significant time would be needed to overcome initial difficulties and find the right ratio of binder and fillers. Also in the end in most of them, it would be very difficult to ensure that no residues would be left behind in the cracks of the paint surface. Therefore, the use of a plastic barrier film between the paint surface and the silicone mould was explored and adopted instead.

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<sup>28</sup> Assistant Professor in FCT, Biochemistry and Biophysics Section.

**Table IX.1** - Alternative explored materials for casting the painting texture.

Material	Advantages	Disadvantages	Trial results (model painting)
<b>Marzipan</b>	Moulds surface texture effectively. Can be removed from infill strip by washing off with water.	Possible residue on painting of sugar and almond paste attractive to insects and a humectant. Requires uniform pressure to take the impression evenly.	Difficult to manage since it does not harden and needs a significant thickness to remove without distortion. Initial trials were too sticky, adding solids resulted in reduced texture moulding and cracking of the marzipan.
<b>Darwi®Extra Light Modelling paste</b>	Takes impression very well. No shrinkage. Long working time. Removal from infill strip with water.	Difficulties achieving even thickness. Significant pressure was required take surface impression. Ingredients unknown.	Sticks to the surface and leaves residue in cracks on the model painting used in trials.
<b>Kaolin + Mowiol 4-88</b>	Possible to adjust the ratio of inert to binder to obtain the right consistency. In theory should be capable of washing off infill with water.	Time required to test and find the ideal ratio of binder to inert.	Produced soft putty- similar to Darwi®. Takes a good impression but sticks to model painting and was difficult to remove cleanly.
<b>Chalk + Isinglass</b>	Flexible, minimal shrinkage.	Time required to test and find the ideal ratio of binder to inert.	Not tested.
<b>Dough consisting of wheat flour and water</b>	Possibility to control the thickness and can be washed off infill with water.	Time required to test and find the ideal ratio of binder to inert.	Tested the making of the dough, however when it was capable of taking an impression it was too sticky, adding flour made it too hard and did not take a good impression.

### **Appendix IX.2 – Production of the replacement strip**

**Table IX.2** - Selection of infill materials

Binder	Filler	Observations
Rabbit Skin Glue	Chalk	Based on previous experience Devesa and Conde [3,47] with these materials, it was felt that all films formed in the required thickness and size would be too brittle to be handled prior to lining, and once in place could form an independent cracking system visually incompatible with the painting. Steps to overcome this problem, such as infusing a cast film with BEVA® 371 to impart flexibility were not explored since other alternatives with flexible materials were available.
Gelatin		
Isinglass		
Mowiol 4-88 (PVOH)		
Mowilith DMC-2 (PVA)		
Lascaux 4176		
Aquazol 200 or 500		
Wax-Resin	Chalk + Pigments	These materials were all flexible enough. Wax-resin was rejected due to the unpredictability of its behaviour in high temperatures. Therefore the BEVA® options were the more favourable choices.
Modified BEVA®371	Kaolin	
BEVA® Gesso-P (BGP)	‘compressible, inert mineral powder’	



Pilot test were performed with BEVA® Gesso-P to assess its properties and establish how best to use it. These empirical tests led to greater knowledge of BGP which shaped the course of the strip production. Some of the trials and results are summarised below:

⇒ Hot-melt: when heating Beva Gesso to ~70.5°C, it never became very fluid. When applied, it cooled almost immediately and picked up on itself during attempts to spread it. Applied on a glass slide, it presented a very rough top surface.

⇒ Solvent diluted: A) White Spirits B) Toluene. With white spirits the solution was more difficult to achieve, and did not confer advantages. Therefore the test proceeded to toluene. Dilution was approx. ¼ toluene to ¾ stock BGP by volume. This gave a fluid but not runny material. It could be applied on top of the silicone mould with a brush or by a flexible green plastic squeegee. It was hard to get an even surface with a brush; but when built in layers with the squeegee it was possible to gain control over the thickness with a series of thin layers (drying between each application).

- The thin film did not crack on drying
- Original diluted BGP can be kept on a covered plastic container and will remain the same, without the need to add more solvent.

⇒ Due to the difficulty in evaluating the accuracy of the texture transfer from painted surfaces a new mould was made with scored lines on plastic, to give an obvious impression. This was an excellent example of how one 'test/trial' leads to another which explores specific questions with more precision.

⇒ Small casts using Duplosil® (silicone mould) were made to establish:

- Whether the texture casting was sensitive enough to a low profile, and if an even silicone mould film could be achieved. This evolved to the refinement of cutting off the edges of the mould to ensure a uniform surface (that could consequently be placed against thickness guides).
- The use of a protective layer over the painting surface (a plastic sheet). With positive results.
- The surface sensitivity of the BGP. As well as exploring thickness issues: trials with multiple applications and solvent dilutions (Table 6).

The development of the final application method was possible only because of the trials with layers, drying times, and by adjusting the thickness guides.

**Table IX.3** – Solvents tested on BGP and Duplosil®.

	Shellsol A	Xylene	Toluene	Shellsol D40	Shellsol T	White Spirits
Aromatics( %)	>97%	100%	100%	<0.4%	<0.05%	16-20%
Relative Evaporation Rate (ether=1)	45	13.5	6.1	55-70	123	-

Solvent Information compiled from the following:

Shellsol:

<http://www.shell.com/global/products-services/solutions-for-businesses/chemicals/products/solvents/hydrocarbon-solvents.html>.

Toluene and Xylene:

[http://www.siegwerk.com/fileadmin/user\\_upload/cc/Data\\_Sheets/TM/Verdunstungsgeschwindigkeit\\_e.pdf](http://www.siegwerk.com/fileadmin/user_upload/cc/Data_Sheets/TM/Verdunstungsgeschwindigkeit_e.pdf)).

White Spirit values, the Supplier Valente & Ribeiro Lda, (oral communication).

### Appendix IX.3 – BEVA® Gesso-P analysis

#### ➤ Binder Identification

Through  $\mu$ -FTIR analysis, it was possible to confirm the presence of the 'BEVA® resins' by the characteristic bands of ethylene/vinyl acetate copolymer mixed with a ketone resin at  $2919\text{cm}^{-1}$  and  $2850\text{cm}^{-1}$  (C-H stretching),  $1738\text{cm}^{-1}$  (C=O stretching),  $1448\text{cm}^{-1}$  and  $1372\text{cm}^{-1}$  (C-H bending) and  $1239\text{cm}^{-1}$  (C-O stretching) [42] (Fig. IX.1). Another material was evident with a strong band around  $1066\text{cm}^{-1}$  (possibly the filler). It was not possible to identify this material further since characteristic bands could be hidden by the synthetic resins peaks. Oxidation inhibitors, UV stabilizers and the pH buffer were not possible to recognise in the spectra probably because of the small concentration present in the mixture. Other analytical techniques would be necessary for the identification of these components.

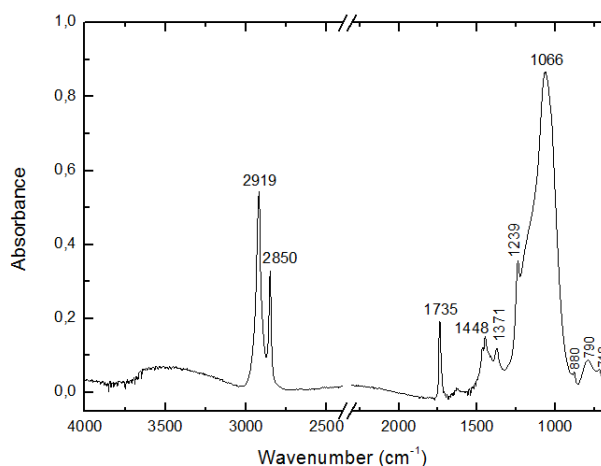


Figure IX.1 -  $\mu$ -FTIR spectrum of a BGP sample.

#### ➤ Filler Identification

The given information by *Talas* is not conclusive regarding the material, stating only its properties: “compressible, chemically inert fine grained mineral powder” and that “The fillers used are crystalline materials of high porosity, and therefore of greatly increased volume and low density. The filler is insoluble in water (its water absorption is less than 1%).” [23]. There is other piece of information, provided by Berger’s recipe to make BEVA® Gesso, saying: “pour guilder’s whiting<sup>29</sup> slowly into the mixture (BEVA® 371, Xylene and Naphtha)” [33]. To try to identify the filler,  $\mu$ -Raman, SEM-EDX and  $\mu$ -EDXRF analyses were performed since  $\mu$ -FTIR did not provide a clear result.

The  $\mu$ -EDXRF analysis indicate the presence of Ca, Fe and Si, while  $\mu$ -Raman spectra show the clear presence of calcium carbonate by its characteristic bands at  $157$ ,  $281$ ,  $711$  and  $1085\text{cm}^{-1}$  as well as some other material which bands could not be attributed. However SEM-EDX spectra (Fig. IX.2) show, apart from Ca and C, a strong presence of Si, Al and O which seems to indicate the presence of an Aluminosilicate mineral. More studies are required in order to provide a more specific answer to this question.

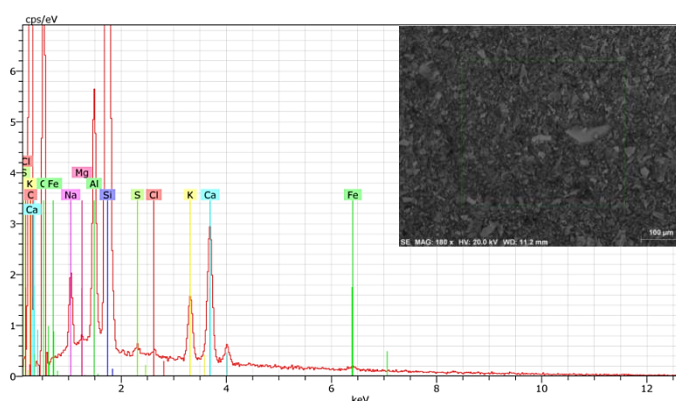


Figure IX.2 - SEM-EDX spectrum of a BGP sample.

<sup>29</sup> Guilder's Whiting is a very fine variety of natural chalk [17].

## APPENDIX X – FUTURE ENVIRONMENTAL CONDITIONS

According to Ana Duarte<sup>30</sup> [personal communication to Joana Devesa, 2012], this painting will be stored in the storage room of the *Core of Quinta da Trindade from Ecomuseu Municipal do Seixal of the Division of History Heritage and Museums of the Municipality of Seixal*.

This storage room does not have environmental control systems. And the room monitoring indicates a cold, moist but very stable environment, both for daily and seasonal cycles, with very gradual changes. This is related to the location of the storage room (ground floor, with an exterior wall) and the building characteristics (old very thick walls – approx. 80cm, in limestone masonry lime plastered and stuccoed). The RH is always above 60% being most of the year between 65% and 70%, only very exceptionally reaching 80%. The temperature fluctuates between 10/12°C and 18/20°C, staying around 15°C the majority of the time.

The people in charge try to isolate the most sensitive objects from temperature and RH and even create a more favourable microclimate through packaging systems and storage materials, including the use of a desiccant (silica gel).

In the case of temporary exhibitions, the same problem is present since the spaces are not environmentally controlled, and frequently are located in industrial buildings with original architecture. Therefore environmental control within the conservation of collections reference values would be unsustainable and in some cases incompatible with the preservation of the buildings themselves.

For exhibition the development of a framing system that creates a microclimate, would be the required solution.

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<sup>30</sup> A staff member of the division of Historical Heritage and Museums/Ecomuseu Municipal - Conservation Service and General Inventory of the Center Quinta da Trindade.

## APPENDIX XI – EQUIPMENT AND SUPPLIERS

### Appendix XI.1 – Equipment

#### **Hot/Cold Vacuum Table:**

Combined BMZ low-pressure hot stage standard, Hofmann und Schildbach GmbH, Restoration Equipment from Sachsen, Breithauptstrasse 4, 08056 Zwickau.

#### **Heat Spatula:**

Willards of Chichester, Sussex, England. Controller type 'E'. Serial No. 0471-479.

### Appendix XI.2 – Suppliers

Product	Supplier	Date of Receipt
Facing tissue: (Japanese Tissue) Filmoplast J; 8.5 g/m <sup>2</sup> thin, transparent technical Japanese paper; raw fibre: 100% Manila fibre	NESCHEN Documents	FCT-PNT Stock
Strip lining white Polyester Fabric: Polyester Restoration Fabric Thread count 51x23cm <sup>2</sup>	Russell & Chaple UK www.randc.net	FCT-PNT Stock 2011
BEVA® 371 film	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de	
Duplosil®, 9°-10° shore A, two components A and B. Simed, Dental equipment and products	Deffner & Johann GmbH http://www.deffner-johann.de	
Lining fabric: Polyestergewebe P110 ecru 215gr/m <sup>2</sup> Breite 314 cm Nr. 2742320 Thread count 20x20cm <sup>2</sup>	Deffner & Johann http://www.deffner-johann.de/	FCT-PNT Stock 2014
BEVA® 371b (Gustav Berger's Original Formula® 371, 40% solution)	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de	FCT-PNT Stock 2013
BEVA® Artist Gesso-P	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de	Purchased 2014
Thin flexible sheet of plastic: Rigo® low-density polyethylene (LDPE) with 0.0005 cm thick.	Hardware store Leroy Merlin, Lisbon, Portugal www.leroymerlin.pt	
White plastic thickness guides: Perfil liso PVC branco (0.2 cm thick)	Hardware store Leroy Merlin, Lisbon, Portugal www.leroymerlin.pt	
Plextol K360	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de	FCT-PNT Stock 2012
Plextol D540	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de	
Acrylic Rohagit SD 15	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de	